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THE LIVING UNIVERSE

Fundamentum veritatis
Deum creatorem et
patrem cognoscere

Henry Ignatius
June 2/20

Deus tibi auxilio
semper sit.

HENRY TRURO BRAY

THE
LIVING UNIVERSE

By

Henry Truro Bray

A.M., M.D., B.D., LL.B., LL.D.

Author of "God and Man," "Reason and Dogma,"
"The Evolution of a Life," etc.

THIRD AND REVISED EDITION

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ELUCIDATIVE

About 25,000 copies of the author's works have been sold to the best educated minds in the United States. Considering the age in which we live, this is highly encouraging.

The universe is full of mystery. Wherever mystery is found, there is a natural desire to fathom it; and though we often fail in our attempts, nevertheless to continue the search after the truth, is better for the advancement of man than to have discovered it.

In this the third edition of THE LIVING UNIVERSE we wish to state the elements of the problem which we believe is solved in GOD AND MAN and THE LIVING UNIVERSE, and add such explanation as may make their meaning clear.

SUBSTANCE is that which is, that which underlies all phenomena. It is homogeneous, uncreatable, indestructible, universal, eternal. These attributes can be referred to GOD alone. Therefore Substance is divine.

MATTER is sometimes used synonymously with Substance, but should not be. Matter is Substance as cognized by the senses, or as known through the modus operandi of consciousness. There is no mind apart from matter, no matter apart from mind. They are correlatives. A knows B through the senses, but B may not be to C as he is to A; nevertheless the substance of B does not depend on the thought or sensation of C: it remains the same, whatever A or C may think of it.

BEING is SUBSTANCE. These words are strictly synonymous.

EXISTENCE is that which is. It is BEING or SUBSTANCE.

FORM is not EXISTENCE. It is said of outline in space.

TIME is the measurement of finite activity. It is not EXISTENCE, not BEING, although inseparably connected with all our reasoning concerning it.

SPACE is not EXISTENCE, not BEING; but there must be said of it, what we have said of TIME: it is a fundamental concept in all our reasoning concerning EXISTENCE.

REALITY is used as SUBSTANCE or BEING.

ABSOLUTE is used of that which is incomparable. It is perfection in itself, and is wholly alone, there being nothing like unto it. The ABSOLUTE is GOD. All drops are of the nature of that from which they come. A drop from the sea is sea-water, but not the sea; a portion of Substance is divine, but not GOD. All Being is of the nature of the one and universal SUBSTANCE. This SUBSTANCE is GOD.

RELATIVE is used of things that can be compared—things that are comparable. Relative is therefore opposite to Absolute.

HOMOGENEITY is used of things everywhere the same in structure or constitution.

HETEROGENEITY is opposed to Homogeneity. The one is sameness and unity, the other is difference and plurality.

REASON is that power which enables one to compare, examine, choose, conclude and act accordingly.

KNOWLEDGE is the agreement of the cognition with the thing cognized. When a thing is known, there is harmony between the knower and the thing under consideration.

CERTAINTY may be said to be the consciousness of this agreement.

BELIEF may or may not be KNOWLEDGE. It is an attitude of the mind assumed by one who has been led or persuaded to adopt it by the attitude or persuasion of another.

FAITH is formulated Belief, and therefore may or may not be true. Belief and Faith, from the very nature of their definitions, must be subject to the reason.

RELIGION is the aspiration of the finite mind after harmony and communion with GOD. There are truths and false statements in every religion; and the superior excellence of any religion is to be determined only by its superior results in the betterment of man.

RIGHT and WRONG with every finite being must be relative. There are those who hold that man has a knowledge of what is called natural right and natural wrong; but our position is that WRONG and RIGHT, generally speaking, are held of such institutions, conditions, or activities prevailing among men as are believed to be the most productive of their respective welfare, and have been adopted by them for local, national, or international guidance after repeated attempts, for hundreds or thousands of years, to find a standard for human guidance in man's relationship to man. Absolute right man does not and can not know. GOD alone is absolute right; and to comprehend or fully understand the Infinite is the problem of eternity. In some considerations we must be content with belief or faith, being always careful to guard against everything contrary to reason. We may be sure that much of what is called right today, may be held wrong tomorrow; and much of what is called wrong today, may be held right tomorrow.

LIFE and DEATH are opposites. All Substance is alive. The form alone dies, the individuality, the personality. In this sense nothing escapes death. Every atom, and every system of atoms; every molecule, and every system of molecules; every globe, and every system of globes; every system, and every system of systems dies. Whatever has an origin must have an end, unless rejuvenated by GOD; but it is the form only that dies. The Substance has neither beginning nor end.

□ Why? Su
to c cha
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SPIRIT is used sometimes synonymously with Soul; sometimes to denote the sum total of the vital forces.

SOUL is substantial, and in substance near to the Absolute. While such an entity must therefore be indestructible, it does not necessarily follow that its individuality or personality is likewise endless. All beings have souls, for Substance is one and universal; but it is not probable that all souls are immortal.

IMMORTALITY denotes the continuity of the personality after death. It is not unreasonable to hold that GOD adjudges those worthy of immortality who, in this life, evolve a noble character, and endeavor to live in accordance with the divine will.

HENRY TRURO BRAY, 1920.
1216 Carmen Avenue, Chicago.

PREFACE

It is not at all probable that the author will ever write another book; nor would he be inclined to publish this, did he not feel that he owes it to the world. Socrates told the Court that he was moved by the indwelling Spirit to teach as he had taught; and thousands of others before and since have felt compelled to give utterance to thoughts not altogether originating in themselves. And if it is true that the Universal Mind may thus cause to vibrate the brain or the soul of the devout and sensitive scholar who, in realms of thought where positive science gives no determinate answer to his question, having used in vain all known philosophic and scientific aids, has devoutly and earnestly attempted to give voice to the silent whisperings of the Universal Self, who is never far from any of his creatures, surely it is neither a conceit nor blasphemous nor irreligious nor irrational for the writer to hope and believe that help at times may thus have been given him.

It is now about twenty-two years since the writer was deposed from the Episcopal Church. He still has no hard feeling against the bishop who deposed him, nor does he feel any repentance for having set forth teachings that led to his deposition; nor will he ever forget the great kindness of those to whom he ministered.

Without professing to have said the final word on the subjects concerning which the arguments and theories in this book are made, being a hard student and having been one all his life, and in addition to his natural love of study and assiduity in prosecuting it, having had a broader and more varied experience than but few of his kind, and completed full courses of study in Medicine, Law, Divinity, Science and Arts, and Philosophy, receiving no less than six degrees from such well-known institutions of learning as Victoria University, Toronto University, Michigan University, Drew Theological School, and Hahnemann Medical College, Chicago, the author feels he is, and believes that the reader should so consider him, comparatively well conversant with the subjects here investigated; and he does not doubt that the conclusions drawn from his life's studies and experience, and carefully set down in these pages, will stand the test of all true scholarship of the present, and be increasingly approved in the future. He is not unconscious, however, of his own limitations; but he is nevertheless equally confident of having kept within them.

The shadowy, fleeting character of everything human, when compared to the abiding reality of Eternal Being, often makes the thoughtful and devout mind hesitate, lest writing hastily, carelesly, or immaturely he may long bitterly and vainly regret having led the weak and confiding astray, or offended that Majesty through whom and in whom we are, and in accordance with whose divine will it should be man's highest aim to live. If we can not beautify or add something of lasting value to what man has already done, we should not mar nor bury it with incongruous material or valueless débris. Our life is too short for repentance. We need every moment allotted us for good thoughts, good deeds, noble aspirations. It is day now, but even already the night is setting in.

With reference to the question of religion the author would say that if these pages are not religious as well as scientific, they are not in his likeness; for as he always aims at living religiously, ever seeking to worship the Divine Presence, and to be guided by it, so thus he tries to write, and thus does he hope to die.

THE AUTHOR.

Chicago, U. S. A.

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THE LIVING UNIVERSE

CHAPTER I

THE SUN

ITS ORIGIN

THE purpose of this book is to make the reader acquainted with the universe as it really is, and as the author believes it to be. For more than twenty-five years the writer has been forced to see in it the true womb out of which all beings spring. Many of the ancients had an incomparably more correct conception of it than the people of these latter ages. We are prone to see in it only so-called matter and blind physical force; unable to recognize the fact that every power whatever, whether it be that which ministers to the sick and dying, betrays a trust, explores the secrets of nature, rules an empire, makes the matricide, scoffs at holy things, or adores the majesty of God, is wholly and exclusively the offspring of that eternal existence we call the universe. We shall see that there is not, and can not be, any other source for the force that moves us to long and sigh for the past, or to dread or hope for the future; to depict on the canvas the loftiest conceptions of art, or master the profoundest problems of science and philosophy.

In what manner may one most readily and truly grasp the truth that reveals the universe as it is, and not merely as it seems to be? We know an acquaintance from his physical appearance, his size, his height, the color of his hair and eyes, his peculiar gait or step, the sound of his voice, his disposition, and even from the character of the acts alleged to have been done; also from deeds charitable, benevolent, domestic, social, or political. Thus may we study the universe. We can first examine it in its grosser aspect, then in its finer or more hidden; or first macroscopically, then microscopically. As we first observe man's exterior, his size, form, color, gait; so thus we believe it is best first to examine the universe, beginning with the study of that which is near and evident, and ending with that which is distant and obscure.

It is said that a nod from the great father of both gods and men was among the immortals the highest sign of assent; and that no promise he makes is ever recalled, or deceptive, or unaccomplished. So great indeed among the gods is their reverence for Zeus that Homer says, "All the gods rise from their seats in the presence of their father; none would dare await his approach, but all arise as he enters." (Iliad I 533.) But if Zeus is thus great among the gods, not less great among the members of our system is the resplendent luminary we call the sun. When the ambrosial locks of the head of the immortal king shook, the whole of mighty Olympus trembled; and no less does every member of the solar system respond to every movement of the great king that sits in majesty upon his central throne.

Few indeed are they who have any adequate conception of our relation to the sun, his relation to us, or of the part he plays in all we think, or do, or hope for. Certainly it is not too much to say that whatever we are, whatever we do, the sun in some sense or other is present with us; for without him we can do nothing. Let him refuse his aid, and our energies becoming equally distributed, we are no longer disturbed by conflicts without nor fears within; but equilibrium being perfect, death reigns supreme. While we live, he is omnipresent with us; and of that presence we have such clear and irrefragable proof that there remains no room whatever for doubt; and while we act, he remains the unquestionable fountain from which springs all our strength to do and dare. Of this the physicist is made aware by the whole phenomena of nature; and of this there is not one so ignorant as that by reasonable use of his faculties, he may not have every doubt removed. For a great number of years England has had her ships on every sea. What carried them there? The wind. What is the wind? A movement of the earth's atmosphere, produced by the impingement on it, and on the earth, of the ether waves set in motion by the sun's energy. The ship had rotted on the ocean's surface, the ocean itself had become as motionless as the immovable hills, and the mast had fallen piecemeal on the silent depths, were it not that the might of the sun's arm had averted these catastrophes. Go into what country you please, or set your foot on some obscure island, there will you find the productions of great manufacturing nations. How came they there? Had a thousand blast furnaces not roared, a hundred thousand anvils not rung, and as many benches not rattled under the incessant effort of a thousand times ten thousand, not a jack-knife would have scraped the bone in the hands of the savage, nor a pin held together his gaudy costume; but none of these things would have been possible had not the sun, out of his seemingly inexhaustible store, given unto the manufacturers the energy to produce them. Were it not for him, the steam had never moved a piston, the piston had never moved a crank, the crank had never turned a wheel, the wheel had never moved the belt, the belt had never turned the lathe nor the drill nor anything else, the wheat had never grown in the field, nor the grass in the meadow, the oxen had never fattened, the workman had never had his dinner, and the workshop had never been opened, nor would the mechanic have had a desire to work for his wife and little ones. There is not even a grain of soil on the earth that is not of the sun's making. Every cloud that floats so gracefully over us, every lightning flash, every roar of the thunder, every drop of the sparkling water, every crystal dew-drop, every feathery snowflake, every hailstone, every storm that terrifies, every zephyr that cools and delights, every movement of the graceful shade-tree, every adornment in our parks and cities, every particle of food we eat, every inch of clothing we wear, every movement of our muscles, every throbbing pulse, and every brain-vibration, all these and infinitely more come to us from the storehouse of the sun; in fact, without him, we who boast so much must give up life's activities altogether, and absolutely and permanently cease to be. Even Nature herself seems to acknowledge him to be among the greatest of her handiwork; for everything born of her is impressed with a deep consciousness of its dependence on him. The tree rises to meet him, and gracefully bows before his presence; the flower tries to touch his garments as the king of day passes by; the storm runs wild with delight, and in his presence becomes intoxicated with joy; the calm, in most pensive mood, meditates on his greatness, beauty, and influence; the moon puts on her most beautiful garments, and quivers with pleasure in his presence; every head in the wheat field in unison makes its bow, and waves of delight roll over it, from end to end, at the coming of the king; and everything, even the mighty mother-earth itself, goes into mourning at his departure, even putting on sackcloth and ashes, and hiding in appalling darkness, refusing to see or to be seen until his coming again. These things being true, it is no wonder that humanity in general has worshiped the sun, regarding him as the fittest symbol of the Deity. Helmholtz tells us that our forefathers were right in regarding the sun as the giver of all life, as the ultimate source of all that has happened on the earth. Says Tyndall: "He rears the whole vegetable world, and through it the animal; the lilies of the field are his workmanship; the verdure of the meadows, and the cattle upon a thousand hills. He forms the muscles, he urges the blood, he builds the brain. His fleetness is the lion's foot; he springs in the panther, he soars in the eagle, he glides in the snake. He builds the forest, and hews it down, the power which raises the tree and wields the axe being one and the same. The sun digs the ore from our mines, he rolls the iron, he rivets the plates, he boils the water, he draws the train. He not only grows the cotton, but he spins the fibre and weaves the web. There is not a hammer raised, a wheel turned, or a shuttle thrown that is not raised and turned and thrown by the sun." And says Youmans: "In the fall of the avalanche, the roar of the cataract, and the flow of rivers; in the crash of thunders, the glare of lightning, and the swepe of tornadoes; in the blaze of conflagration, and the shock of battle; in the beauty of flowers, of the rainbow, and the ever-shifting clouds; in days and seasons; in the silent growth of plants, and the elastic spring of animals; in the sail-impelled or steam-driven ships, and the flying train, in the heavy respiration of the laboring engine, and the rapid click of the telegraph; in all the myriad manifestations of earthly power, we behold the transmuted strength of the all-energizing sun." Such being the work of the sun, and such his character, we can not well fail of a strong desire to know something of his origin, condition, nature, and end.

As the sun as such can not be eternal, he must have derived his energies from some other source of power; and as it is equally plain that every form of power we know or think of, is but a change from some other form or forms, it follows that it is most reasonable to hold that the sun himself, as an entity, must have received his being from the transmutation of some other forms of energy or existence. Thus while the substance of the sun, as all other substances, seems stamped with eternal life, the sun itself, as a body, has derived his existence through the destruction of other forms. The whole visible creation, as far as we know it, is subject to constant change, and all its varied appearances are but the changes and transmutations of things that were into things that are; the former, as individuals, having ceased to be, though retaining a certain kind of immortality in the existence of their successors. This truth so generally held to-day has been quite extensively received by the most scholarly in all ages. Says Aristotle: "*καὶ καθάπερ οἱ ἓν ποιοῦντες τὴν ὑποκειμένην οὐσίαν τάλλα τοῖς πάθεσιν σὐτῆς γεννῶσιν*— So also are there those who, making the underlying substance one, explain all the others through the changes of it." (Meta. 1 4, 10.) To a correct understanding of the origin of the sun, it is necessary that we have a correct understanding of the nature of our cosmos as a whole. We should think of it as a single machine, as an inseparable whole. To this whole there can be no source of gain, and from it no place for loss; but in it there is endless transmutation. In the words of Helmholtz: "The universe has its definite store of force which works in it under ever varying forms; is indestructible, not to be increased, everlasting and unchangeable like matter itself." We should have preferred the use of the word substance to the word "matter" in this quotation; but we can not fail to see that whatever force there is in the sun, must have previously existed in the universe in some other form or forms. The only question is, whence did the sun acquire his energy? How was it produced in the form it is in today?

The good book which comes to us through Jewish civilization, and which we have adopted as our own religious storehouse, undoubtedly teaches that the sun is a special act of creation, which act is there said to have been performed on the fourth creative day. That this is the teaching of the Bible I presume no one will for a moment doubt. But as science for the last three hundred years has raised her head among the stars of heaven, and descended down into the earth's great depths, explored the silent deep, penetrated the everlasting hills, examined the constitution of the sun and stars, and searched into the very being of matter itself; as she has dethroned the earth from the false position which theology for five or six thousand years had given it, the position of ruler and centre of the universe, the position of queen before whom every star, sun, and planet made its obeisance, and for whose glory, and to manifest whose beauty, the sun, moon, and stars made daily circuits around her to flood her path with light, and to enable her more fully to display her bewitching charms,—since science has dethroned the earth from this false position of queen and empress to that of kitchen-maid, from the most exalted position in our universe to the most insignificant; and since science had done this so thoroughly, and made so manifest its work that the poor way-faring man, though a fool, may not be mistaken, theology has indeed been forced to make many apologies, and conjure up as many labored excuses, even to affirm that she was mistaken in the interpretation of her text-book, though at such naive acknowledgment science can but smile. Nevertheless, it is not a true sign of manhood to strike a man already down, and asking your pardon, or trying to be friends at any price. We believe, however, that there is not one truly educated man in the world who believes the old story as interpreted by the church for nearly two thousand years, and found in various religious books, especially in the first book of the Bible, concerning the origin of the solar system. Science to-day speaks with wonderful power. Her voice goes out through the whole world. She who once was despised by the church, and kept in prison bound with chains; she who was burnt alive, and whose ashes were cast to the four winds of the earth, has now become such a power that the whole world listens; and her ancient enemy, pressed to the ground, seeks to make overtures for peace.

It is quite popularly held, and in the past it has been somewhat extensively taught, that the sun derives his energy from the product of combustion; that is, that he is a large body all on fire; and that thus burning, like a piece of wood, he will radiate his heat on other bodies within reach until he is entirely consumed. But when the physicist of to-day applies his accumulated knowledge to the examination of this question, he evidently finds no possibility of the truth of the popular theory. Suppose, for instance, the sun to be composed of substances which weight for weight produce the greatest amount of heat. Let the sun be wholly composed of hydrogen and oxygen in the proportions that enter into water. Now the mass of the sun is well known, as also the amount of heat produced by the union of known amounts of hydrogen and oxygen. Standing on these known facts, Helmholtz shows that were the sun composed bodily of these two principles, it would only suffice to keep up the present radiation for three thousand and twenty-one years. The sun's radiation of energy is set down as corresponding to 100,000 horse-power for each square metre of its surface continuously acting, that is, over a million calories per square metre a minute. Every square foot of the sun's surface gives forth 46,000 times, each minute, the heat received on the earth during that time on each square foot. It is said that if the sun were completely frozen over to a depth of fifty feet, his radiation of heat is so great that the whole shell would be melted in one minute. Young says that "the heat annually received on each square foot of the earth's surface, if employed in a perfect heat-engine, would hoist sixty tons to the height of a mile." It is evident that at this rate, were it wholly dependent on his combustion, the sun's radiation could last, comparatively speaking, but a short time. It is supposed that it could not last longer than 8,000 years But eight thousand years, though much with man, is scarcely anything compared to the vast time during which the earth has been flooded with light and heat from the sun. If his radiation had depended on his combustion, he would have become a dark body millions of years ago, whereas his temperature is set down now by Siemens as 3000°C. It can not be doubted that the earth gives us the most irrefragable testimony, in the biography which she has written with her own hands, to the truth of the fact that she has been for many millions of years, probably some hundreds of millions, receiving from the sun as much heat as she receives to-day. And since a body of the limited dimensions of the sun, though it were composed of the most heat-generating principles, could not give out such a store of energy except for a fraction of this time, it follows that the idea of combustion being the source of the sun's heat must be entirely given up for one more acceptable, and more in accord with present scientific knowledge.

That the sun must be at an enormous temperature we are sure from the character of the light and heat he radiaates. If an iron ball be heated to what is called white heat, it becomes visible, and may be photographed by its own light. From it will radiate the heat ray, the light ray, and also what is called the ultra-violet ray. If its temperature be still increased, the proportion of violet and blue rays will be so large that the ball will look blue, and may be called blue-hot. As the ball loses its heat, the more rapid vibrations cease, the ultra-violet rays die away, and the body becomes more and more difficult to photograph by its own light. The light now becomes yellowish, the yellowish light becomes orange, and the orange becomes red. The body is now difficult to photograph, although it be perfectly visible. When the heat of a body is less than 525°C. we fail to see it in the dark, although its warm rays make us sensible of its presence. All the rays mentioned come to us from the sun; for when we decompose sunlight, as is done in the spectrum of the sun, we have the lowest heat ray, the red, and the highest heat ray, the ultra-violet. Rays of higher and lower refrangibility are undoubtedly there; but our organs are not sensitive to them, our range of vision, as well as that of hearing, being very limited. Few comparatively are the sounds we hear, and few the sights we see.

So high is the temperature of the sun that not less than twenty-five per cent of his whole radiation is luminous. When such a body as the ball we have mentioned ceases to be visible or felt, we must not infer that it ceases to radiate; the truth is that while it has ceased to radiate such rays as affect our nervous system, it nevertheless keeps on radiating until every surrounding body is raised to a temperature equal to its own. Thus is it with the centre of the solar system; being at a higher temperature than any of his planets, he is constantly radiating heat and light, and by so doing raises their temperature at the expense of his own. In return for all he does for them, they give back some of their borrowed heat; but he always loses enormously more than he gets back. This interchange must be kept up with constant increasing loss to the sun, until, as in the case of the ball and its surroundings, the sun becomes reduced to the same temperature as that of his system in general. When that time shall come, and come it surely must, all things will be equally warm, equally light, equally active; in other words, our solar system will be dead, every form of so-called life millions of years before having been carried to its grave.

The general and perhaps universally received opinion concerning the origin of the sun's heat is thus given by a physicist second to none in the world to-day. Says Sir William Thompson: "The essential principle of the explanation is this: At some period of past time the sun's initial heat was generated by the collision of pieces of matter gravitationally attracted together from distant space to build up its present mass; and shrinkage due to cooling gives, through the work done by the mutual gravitation of all parts of the shrinking mass, the vast thermal capacity in virtue of which the cooling has been, and continues to be, slow. Think of two solid globes, each of the same mean density of the earth, and of half of the sun's diameter, given at rest or nearly at rest, at a distance asunder equal to twice the earth's distance from the sun. They will fall together and collide in a half a year. The collision will last but a few hours, in the course of which they will be transformed into a violently agitated incandescent fluid mass with about 18,000,000 years' heat ready made in it, and swelled out by this heat to possibly one and a half times, or two, or three, or four times its present diameter."

Such a theory of the sun's heat rests on a sound physical basis, and appears perfectly adequate for the explanation of the otherwise inexplicable problem; and it does not require any stretch of the imagination to suppose such a sun coming into being from the collision of worlds, when we see similar phenomena every day of our lives. It is not necessary, however, for us to hold that the sun's initial heat was generated by the coming into collison of two bodies and no more. There may have come together a vast swarm of meteors, and formed our central orb, which has ever since been contracting into a more and more solid body. Either theory seems sufficient as offering a cause for the sun's initial heat. Some may prefer one theory, some the other; but I can not but believe that in the vast depths of this universe two lonely, dying worlds, moving in dead silence, hopeless and despairing, might approach each other, and sacrifice, as it were, their worn-out individualities to produce a joint body full of youth and productive power. Such to me is the more probable explanation of the origin of the initial solar heat; but that it is the result, as Helmholtz thinks, of the coming together of meteors, is certainly possible, and contradicted by nothing known in the realm of science. Which of these modifications, or what other modification, of this common theory we adopt to explain the origin of the sun's heat, science is not concerned: but that we hold to some such theory, science seems to insist.

CHAPTER II

THE SUN

CONSTITUTION, RADIATION, AND FUTURE

THE sun is a member of the stellar system: and judging from analogy, it is quite probable that like the sun every star in the heavens has planets and satellites revolving around it. The only difference between our sun and those many millions, called stars, that roll in the infinite depths of space, consists chiefly in distance and size. The sun is a star whose superior brightness is caused by its nearness to us. So near is the sun that he presents us a disk; so distant are the stars that they present us none, not even to the most powerful telescope.

The stars in some parts of the heaven appear packed almost in piles together; and yet wherever the astronomer has succeeded in thoroughly searching into the nature of these piles, as Herschel did in so many instances, it has been found that thick as those stars appear to be, they are in reality millions of miles apart, and frequently thousands of millions of miles. Were a thousand men to stand before us, each a hundred yards apart, we should, if we stood near the column, our line of sight being at right angles to it, see each man some space apart; but as we moved away from the column, the men would appear to approach one another, and the space between them to gradually lessen; and should we remove far enough, the space would wholly disappear, and the thousand men would seem to be one body or even one spot. Thus it is with the stars; were we to approach them, they would seem to grow larger and larger, the spaces between them to widen, until finally they would appear separated from one another by almost inconceivable distances; and in those spaces there would be seen revolving, without reasonable doubt, planets and satellites, as in the case of our own star which we call the sun.

There are about six thousand stars or suns visible to the naked eye, but the telescope reveals countless millions; and there is no doubt that the number thus visible is in proportion to our power to penetrate the vast space that separates us.

No body in the heavens is motionless. The stars, like the earth around the sun, revolve around some distant centre or centres. We have every reason for believing that all our solar system moves around some distant centre; because from observation it is quite generally held that certain stars show unquestionable displacement. From a comparison of the motions of several hundreds of stars, the inference is that our solar system moves toward the constellation Hercules, whose right ascension is 200° and declination 35° north, at the rate of about 160,000,000 miles a year. The centre, however, around which it moves, would be more correctly called the gravitational centre of the stars belonging to our system, than any one globe; for it is not probable that any one body is large enough to be such centre.

We have said that the cause of the sun's initial heat was the collision of two or more worlds. This brought us one globe whose diameter was much greater than the present distance from the sun to Neptune, a distance approaching to 3,000,000,000 miles. The question of the rotation of this globe has been made much of by certain theologians, affirming that here at least there is evidently seen a necessity for divine interference. On the contrary, it seems to us that no phenomena present us less reason for such interference. It is certain that such a fire-mist was more exposed to the cold of space on the outer parts than in the inner; and that this exposure would result in the loss of heat, and in consequent precipitation or condensation of the fire-mist, especially at the surface. This condensed matter would necessarily fall toward the centre of gravity of this fire-mist. Thus would come the first motion according to natural law. Similar motions would be set up from every point of this vast body's surface; and it would be impossible to conceive of so many, each seeking the common centre, never coming into conflict. The moment we conceive the possibility of two of these condensed particles of matter departing somewhat from a straight line in seeking the common centre, that moment we are forced to admit that collision is possible at any time; because one collision necessarily gives rise to another. The result of such collisions would produce a rotation, or a revolution on the axis of the fiery mist. In this way we account for the sun's axial rotation and, as a consequence, for the axial rotations of all the planets and satellites of the solar system. No little proof of such axial rotation is found in the fact that the planets which revolve on their axes with extreme velocity are those of very large dimensions and of vast orbits, such as Jupiter and Saturn; while those that move very slowly on their axes are small in mass, and move in small orbits, such as Mercury. In the bodies of large dimensions the condensed matter had a great distance to fall, and thus acquired very great velocity, enabling it to impart a correspondingly rapid axial rotation. The time of the sun's axial rotation is set down as from 25 to 26 days.

In considering the physical constitution of the sun, we speak of a body in which the materials of our earth exist chiefly in their pristine state or nearly so, a state in which the existence of the elements is impossible. With man there can not be a city without the conditions being present, such as men and organization; for however many be the inhabitants, there will be no city unless they are organized. Thus with matter as we know it. We may say it has become organized; but in the sun there is no such organization or classification. Differentiation has not to any extent taken place in that body as yet.

In examining the sun the first thing we come to is the corona. This is a kind of atmosphere rising to a height of from one to three hundred thousand miles. It can not, however, be an atmosphere in the sense we generally use this term for several reasons: Gravitation on the sun is just about twenty-seven times greater than on the earth. In an atmosphere, as in every other body where particles are piled one upon another, every atom is compressed by the weight of every other atom above it. This results in condensing the atmosphere as we descend successive distances in a geometrical ratio. It is said that an atmosphere of the lightest known gas, hydrogen, would double its density every five or ten miles. The conclusion is that if the corona be an atmosphere it must be composed of matter several hundred times lighter than hydrogen. Again, comets have been seen passing through the corona. The comet of 1843 passed so near to the sun's surface that it really went through some three or four hundred thousand miles of its corona without suffering any apparent loss of substance, or visible retardation. This comet moved through the corona at the rate of 350 miles a second. We can have some conception what would result to such a body, were it to pass through an atmosphere anything like our own at this rate, when we think that shooting stars are generally destroyed by passing through it for only a short distance at the rate of from twenty to forty miles a second.

By some it is supposed that the corona is formed by detached pieces of matter constantly ejected by the sun, which cool and fall back upon the sun again. It is said that a particle of dust, distributed over a cubic mile of space, would shine intensely exposed to the flood of sunlight to which the corona must be exposed. The objection to this theory is said to be the great projectile velocity required to be maintained all over the solar surface, a velocity of not less than 200 miles a second. By others electric repulsion is made the cause which keeps the corona, rare as it is, suspended through such vast heights; and judging from what electricity is seen to do on earth, this is by no means impossible. Again: it is believed by some that the corona is composed of nothing more nor less than clouds of minute meteors revolving around the sun, thus near its surface. Which of these suppositions should be received as the true one, is hard to say. Each may be false; each may be true.

After passing the corona we come to the chromosphere. This is the true solar atmosphere, and it rises a few seconds above its surface, or to a height of from five to ten thousand miles. Immense seas of flame are seen to rise and fall in this atmosphere, a single splash, as Lockyer calls it, frequently rising many thousand miles. But burning in the true sense does not take place here; for, as Newcomb says, the substance of the chromosphere is already so hot that burning is not possible. Burning as we know it is nothing but chemical action, and chemical action is not possible except in a condition where there are different elements having chemical affinity for each other or for one another; and such a condition as this exists in the sun in only a very limited sense. The principal substance of the chromosphere is hydrogen. This element is among the first products of the universal substance; for it is one of the most elementary forms of matter. The waves or outbursts of matter which occur in the chromosphere are said to be beyond all description. They have at times velocities of 150 miles or more a second. "They are such hurricanes as coming down upon us from the north, would in thirty seconds after they had crossed the St. Lawrence, be in the Gulf of Mexico, carrying with them the whole surface of the continent in a mass, not simply of ruin, but of glowing vapor in which the vapors arising from the dissolution of the materials composing the cities of Boston, New York, and Chicago would be mixed in a single indistinguishable cloud." The sun appears lashed into a fury as he hurls these eruptions fifty or sixty thousand miles into space. One of these would be a sufficient "day of judgment" for the earth. It would completely engulf it, in a few moments dissolving every terrestrial thing on the surface of the globe.

In the vapors of the sun the existence of the following substances is affirmed by the most eminent authorities, such as Kirchoff, Angstron, and Thalen: Sodium, Iron, Zinc, Magnesium, Nickel, Barium, Copper, Calcium, Chromium, Cobalt, Hydrogen, Manganese, and Titanium; and there are physicists who assert that we have evidence of the existence in the sun of also Aluminum, Strontium, Lead, Cadmium, Cerium, Uranium, Potassium, Vanadium, Palladium, Molybdenum, Indium, Lilbium, and Ytrium. It is not believed that any of these elements exist in the main body of the sun; for there differentiation has not taken place; they exist in his atmosphere only. In the sun's body below the chromosphere the heat is so great that chemical affinity is impossible; but as the vapors ascend from the hotter to the cooler regions, to some extent these conditions are met that in the past brought into existence the elements we know. On the cooling of the substance it falls back again through its own superior gravity, and thus begins a convection current, which is the prime factor in the solar eruptions. Thus it keeps on ascending and descending, reascending and redescending, helping to produce the violent solar waves which are known to take place there. It is said by Lockyer that if we could lay hold of a solar meteorite, say a hundred thousand miles from the photosphere, and watch it in its downward flight, the solid would first become liquid, then vaporized, giving us the spectrum we are familiar with in our laboratories; and that after that the vapor would still go through a series of simplifications of which we can take no account, because we have not the same temperature. What would happen in this case is that we should know nothing whatever of the state or nature of the substance of this meteor in its final resting place, and this is just as we find the facts in general to be. The spectrum of the region just above the photosphere is one of the strangest things in solar physics. The lines which we see are either altogether unknown to us, or are seen without their usual companions.

Ordinarily neither corona nor chromosphere is seen through the telescope, and of course not by the naked eye. It is in the time of eclipses that the astronomer gets glimpses of these solar parts through the telescope; and it would seem, according to Lockyer, by the naked eye in certain cases and in certain regions.

Next below the chromosphere comes the photosphere, which part is that generally visible. From this comes all our radiation of light and heat. There are different opinions held as to the nature of the photosphere. Newcomb regards the photosphere not as gas but as solid matter. It must not, however, be supposed that he means by this a solid anything like our earth; but rather that it is a gas subjected to such tremendous pressure as to make it shine like a solid.

Although no changes of level have ever been discovered in the photosphere, the numerous photographs of the sun which have been taken by eminent physicists in all parts of the world, show that the photosphere is not devoid of irregularities. Says Dr. Janssen: "The photospheric network can not be discovered by optical means applied directly to the sun. In fact, to ascertain it from the plate it is necessary to employ glasses which shall embrace a certain extent of photospheric image. Then if the magnifying power is quite suitable, if the proof is quite pure, and especially if it has received rigorously the proper exposure, it will be seen that the granulations have not everywhere the same distinctness, that the parts consisting of well-formed grains appear as currents which circulate so as to circumscribe spaces where the phenomena present the aspect we have described. But to establish this fact it is necessary to embrace a considerable portion of the solar disk, and it is this which is impossible to realize when we look at the sun through a very powerful instrument, the field of which, by the very fact of its power, is very small. In these conditions we may very easily conclude that there exist portions where the granulations cease to be distinct or even visible; but it is impossible to suppose that this fact is connected with a general system." It is believed then that the whole photosphere is actually broken to pieces by convection currents; that this apparent solid and glowing mass is in reality in most violent agitation caused by the down-rush of the cooler, and the up-rush of the hotter, lighter matter.

The brighter portions of the sun's photosphere are called faculæ. These parts appear sometimes as if elevations; but they are by no means limited to them; at times they are seen extending ten thousand miles along a perfectly smooth solar surface. These faculæ appear much brighter, and are more easily seen, near the sun's limb than at his centre; and for the same reason that the sun so often appears red at sunrise, because of the greater depth of atmosphere the sunlight passes through, causing more absorption of the blue rays of the sun.

The solar spots occur on the photosphere. These are whirlpools carrying down in their vortices the cooler matter, and upwards the fiercely heated, with almost inconceivable velocity. The cooler matter, consisting chiefly of hydrogen, is supposed to cool for a time the hotter parts of the sun with which it comes in contact, and thus produces the dark spot. Finally, being greatly heated it again ascends with a violent rush far above the normal level of the photosphere through the chromosphere itself, and forms what are called the protuberances. Says Mr. Faye: "A time will come when the vertical movements which feed the photosphere will become more and more hindered. The cooling then will be purely superficial, and the surface of the sun will harden into a continuous mass."

In a sun spot there are the penumbra, the umbra, and the nucleus. These spots are sometimes of enormous dimensions. Mr. Lockyer says that in 1858 one was seen having a diameter across of not less than 140,000 miles, or eighteen earth-diameters. The exact instant when a spot is first formed can not be determined. The phenomena pass from the scarcely disturbed state to the most violently agitated, from insensible markings to the blackest nucleus. A spot often attains its full size in five or six days. The disappearance of a spot is, according to Dr. Peters, brought about thus: From opposite sides of the vast gulf flashes proceed meeting in the middle, thus making a bridge or covering over the vast abyss below.

These separate and recede only again to dart forward until in a few minutes their union is permanent. This phenomenon takes place all over the higher photosphere until all the spot is covered over; but in the deeper part no such bridging is said to happen. This part is left to the forces of dissolution, which complete the work in from ten to twenty days.

Another eminent authority is Father Secchi, who says the sun is an incandescent body of enormous temperature, that this incandescent mass is what constitutes the photosphere, which is full of brilliant granulations separated by a dark net-work. Above the photosphere, he says, lies an atmosphere of a very complex nature composed chiefly of hydrogen, which sometimes rises to heights equal to the whole solar diameter; the body of the sun, he thinks, is never in a state of absolute repose, internal commotion being necessarily caused by the tendency of dissociated elements to combine; the solar spots are formed by masses of absorbing vapors which, brought out from the sun's interior, and interposed between the photosphere and the eye of the observer, prevent a large part of the light from reaching him; the hydrogen vapors, he says, do not produce spots, metallic vapors only produce them; the irruption of simple hydrogen produces faculæ; the solar spots inform us of the violent crises occurring in the sun's interior of which we know nothing. The internal temperature he says can not be less than the external; the sun's radiation has been about constant all through the historical period, and this constancy is preserved through the mass through the contraction of this mass, and through chemical union. The sun's initial heat, he says, must be found in the force of gravitation; the solar temperature, he says, must be one capable of maintaining all known substances in a state of vapor. This temperature is set down to-day as probably about 18,000° F.

Mr. Faye of Paris thinks the velocity of a spot depends on its latitude, and that it is the same as the mean velocity of the zone where the spot was formed. This is probably true. Mr. Young regards the chromosphere as simply the layer of uncondensed gases which overlie the photosphere, though separated from it by no definite surface. The lower portion of the chromosphere is rich in all the vapors and gases which form the sun; but at a comparatively little height the denser and less permanent gases disappear, leaving in the upper regions only hydrogen, and some other substances not yet identified. Young does not know what to make of the corona; but of the sun spots he speaks in words substantially one with those of the authorities already given.

We have said that no miracle is needed to account for the sun's initial heat. Indeed, even Father Secchi says that a gaseous body, having the diameter of the solar system, might acquire by contraction several times the temperature of our sun. On the other hand, it needs no prophet to tell us what must be the end of the sun. We are sure that contraction is inversely proportional to density. As time rolls on, the heat of the sun being more and more dissipated, there will of necessity be a constantly diminishing amount left behind to reduce to vapors the increasingly cooling condensing mass; this must result in a kind of suffocation. The hydrogen clouds will cease to be; nor will the bright, scintillating faculæ be seen any more to play along the sun's molten surface; the sun spots will fail. Finally what has happened to the earth, moon, and other planets, will happen to the sun; the sun will have a solid crust. As his internal heat grows less, this crust will fail to radiate. Little by little will sunlight disappear from the face of the earth; little by little will our frigid zone increase; little by little will our few remaining inhabitants huddle together in the constantly narrowing torrid zone, through the failure of light and heat to supply the wants of a dying humanity, the despairing remnants of once boastful and world-conquering man. To supply the deficiency mechanical means will in certain cases, and for a time, be resorted to; but the "Dies Iræ" comes: light itself finally fails, and with a dying out of light and heat, dies out *pari passu* all we now know of earthly life. It is true the change will be imperceptible as that from youth to old age; but it will be no less real, and universally subversive of all life and activity. This is not a pleasing prospect — the death — the agonizing throes of a dying world; but so is not the death of anything, yet all things die.

The amount of heat and light radiated by the sun comes within the range of calculation. The quantity the earth receives is to the whole solar radiation as 1 is to 2,170,000,000; that is, as the earth's apparent angular magnitude seen from the sun is to the whole celestial sphere. It is evident that such radiation can no more be kept up without solar loss than a man can work without expending the force he has taken into his system in the shape of various kinds of food. Energies are in each case transmuted. The heat emanates from the sun, and traverses space in direct lines, and is lost to the body from which it emanated, except an infinitesimal quantity that may be reflected. As every living thing lives by expending his energies which have been received from the outer world, and dies when expended energies can not any longer be renewed; so the sun lives by expending his energies, and must in time die, there being no source of renewal. Every minute the sun pours on each square metre of the earth's surface exposed to his rays no less than 37 calories of heat.

Light and heat we have said result from contraction, and to a small extent from chemical union. It is held that contraction of about one mile in a century of the sun's diameter will suffice for all our present supply of light and heat. Newcomb holds that after the sun begins to solidify, his light and heat will rapidly diminish. This is certain from the fact that contraction is inversely proportional to density. Solidification, Newcomb thinks, can not be postponed beyond 5,000,000 years; and it is quite improbable that the sun can support life on the earth 10,000,000 years. By some it is not thought probable that the sun can have been radiating light and heat, as at the present, for more than 18,000,000 years, even if in the beginning his volume filled all the space now occupied by the solar system. Newcomb thinks that the sun has not been radiating light and heat, as at present, for more than 10,000,000 years; and that in 12,000,000 years hence he will be as dense as is our earth to-day. Sir William Thompson holds that it is exceedingly improbable that the sun's light and heat have been in the past as at present for a period greater than 2,000,000 years; and that it is equally improbable that it can be continued in the future for a period greater than five or six million years.

We have given all the chief facts concerning the sun, known to modern science. It is true we have not mentioned the fact that solar outbursts are by some supposed to be connected with great planetary disturbances; but concerning this matter our knowledge is very imperfect, and opinions widely differ.

From every conclusion of science we must acknowledge that as in the beginning all the solar energy was available, so in the distant future none will be. While the energy of the sun remains absolutely the same, the proportion of it available constantly decreases. While the available energy is never increased, in the manifestation of every phenomenon it is more or less decreased. Thus is it true that the available energy of the cosmos tends to zero.

We may be sure that as it is appointed unto man once to die, the mandate is equally true of every part of the mighty cosmos; and therefore of that part which is the centre of it, the now glorious sun. Just as the lily of the field, faded and worn, finds nothing in its life joyous, fruitful, or green; as a wretched pauper, homeless, friendless, hopeless, sighs for death and deep oblivion; so the sun, stiff with old age, and finding nothing sweet in life shall hurl itself into the tomb of nature, and shall in due time come forth again in some shape not less glorious than before; and for it there shall be, so to speak, a new heaven and a new earth.

TABLE

Distance 92,900,000 miles.
Diameter 886,400 miles.
Surface 11,813 times that of the earth.
Volume 1,310,000 times that of the earth.
Mass 331,100 times that of the earth.
Density about one-quarter that of the earth.
Density about 1.4, that of water being 1.
Superficial gravity 27.65, earth being 1.
Apparent mean diameter 32′ 04″. Time of axial rotation 24d 7h 48m.

If we were to represent the earth by a ball one inch in diameter, a ball nine feet in diameter would represent the sun. If the sun's centre were at the earth's, his surface would extend to a distance nearly twice as far as the moon is from us.

CHAPTER III

THE PLANETS

MERCURY

OF all the positively known planets Mercury is nearest the sun. It is too near our central orb for easy observation; yet it has been known from great antiquity. Its orbit is inclined to the plane of the equator more than that of any other planet; its brilliancy is equal to that of Sirius. Because of its nearness to the sun it easily eludes our search. The best time to see it is in the west a little after sunset, or in the east a little before sunrise. It is said that Copernicus never saw this planet. It is perhaps safer to say that he never knew he saw it. Mercury has the greatest density of any planet; moves in its orbit faster than any other; has an orbit more eccentric and more inclined to the plane of the ecliptic than any other. Its period of axial rotation used to be given by many astronomers as 24 hours 5 minutes; but it is quite generally held to-day that it always keeps the same side turned toward the sun, and for like reason that has forced the moon to keep her same side always turned toward the earth. Mercury, therefore, turns on its axis only once in 88 days, that is, concurrently with its siderial revolution. The synodic period of Mercury is 116 days. The plane of its orbit is inclined to that of the ecliptic 7 degrees. The planet's diameter is about 3000 miles; its surface about one-seventh of that of the earth; its volume about one-eighteenth; its mass about one-eighth; its density about nine-fourths; its gravity at the surface a little more than eight-tenths of that at the earth's surface. Its apparent angular diameter varies from 5″ to 13″. In making some of these statements we have made choice, good or bad, among much conflicting opinions. Ball, for instance, states that the planet's mass is only about one-twenty-fifth of the mass of the earth, while Backlund says it is one-eighth.

Mercury's mean distance from the sun is 36,000,000 miles; its perihelion distance is 28,500,000 miles, and its aphelion 43,500,000. At perihelion its velocity is no less than 35 miles a second—a race for life; at aphelion it is not more than 23. Its synodic period is 115.8775 days; and its siderial, 87.9694413.

Many believe that there is a planet moving around the sun inside the orbit of Mercury. It has been named Vulcan. It is held that the disturbances manifested by Mercury show the existence of such a planet. If there be such a body it must be very small. There may be such a body, or several such. There may be also meteoric streams revolving around the sun inside the orbit of Mercury. All these suppositions will need further investigation and proof, before they are laid down as facts.

VENUS

This beautiful planet moves in its orbit between Mercury and Earth. It has been known from most ancient times as the evening star, and perhaps as the morning star also. When west of the sun, it is the evening star; when east of the sun, the morning. Its mean distance from the sun is 66,822,000 miles; its diameter is 7666 miles; its specific gravity is 4.8; its periodic time is 7½ months. Being an inferior planet, Venus is never seen far from the sun, its greatest distance from the latter being at a point where a line drawn from the earth becomes a tangent to the orbit of the planet. If at the same time another line be drawn from the earth to the sun, the two lines will form an angle of 47°, and this is called the angle of greatest elongation. As the planet moves away from or approaches us, this angle gradually decreases. When from the point in its orbit nearest to us the planet has moved 180°, it is said to be in superior conjunction; and when it arrives in its orbit between the earth and the sun, it is said to be in inferior conjunction.

Venus, being an inferior planet, moves faster in its orbit than the earth; for according to one of Kepler's laws, the squares of the times of the planets are proportional to the cubes of their distances. Venus takes about 7½ months to complete its circuit around the sun, and the earth takes twelve to complete her revolution. It is evident that when once Venus passes the earth, in order to pass it again Venus will be obliged to make a whole revolution plus whatever space the earth may have passed over during the same time. If, therefore, when the planets are in conjunction, we wish to know when conjunction will again occur, we proceed thus: Venus takes 224.7 days and the earth 365.256 to make their respective revolutions around the sun. The daily angular motion of each therefore is known. If, therefore, when the planets are in conjunction we suppose that they will be in conjunction again in x days, we may find the value of x from the following equation: $ax - bx = 360$. Here a represents the angular daily motion of Venus and b that of the earth. By solving this equation we shall find the value of x to be 583.9214, which is the synodic period of Venus.

When in inferior conjunction Venus is only 25,000,000 miles from us; but when in superior conjunction it is no less than 159,000,000. In the latter position it is farther from us than when in the former by the whole diameter of its orbit.

With the exception of the sun and moon, Venus is the brightest body in the sky. When in inferior conjunction it would indeed shine most resplendently, if its fully illuminated side could be seen by us; but at that time only a portion of its side turned toward us can be seen, for as with the moon so with Venus, it passes through what is known as phases. Its fully illuminated side can be seen by us when the planet is in superior conjunction only, that is, in that part of its orbit most distant from us. When in this position it is about six times farther from us than when in inferior conjunction; and therefore, since the apparent diameter of a heavenly body varies directly as its distance, when in superior conjunction the diameter of its disk is only one-sixth of what it is in inferior conjunction.

To the unassisted eye Venus looks like a mere star distinguished only because of its brightness. When Galileo first turned his telescope upon this planet, he discovered to his surprise that the body presented phases like the moon. It is supposed that at the time Galileo discovered this, the planet must have been in that part of its orbit where it appears gibbous, more than half of its face being illuminated; and after a few months Galileo found that it turned into a crescent. It can hardly be possible that Galileo could have remained long in doubt; for the variations in the aspect and apparent magnitude of Venus are strikingly great. When on the other side of the sun, in the most distant part of its orbit, Venus presents a disk only 10″ in diameter; but when on this side of the sun, nearest the earth, could its whole side be visible, it would present a disk with a diameter of 60″. But in this part of its orbit its dark side is turned toward us, and the planet is therefore invisible excepting an extremely thin crescent of its illuminated hemisphere, and even this is rarely seen. Where the planet would be largest, could its illuminated side be seen, there it appears smallest; and where it should be smallest, there it appears largest.

Cassini in 1667, on seeing a spot on the disk of Venus, on several successive evenings, concluded that the time of the planet's axial rotation is a little more than twenty-three hours and twenty minutes. In 1726 Blanchini of Rome discovered what he thought to be seven spots on the surface of the planet, which he considered seas. These he watched night after night, and finally concluded that the time of the planet's axial rotation is a little more than 24 days. The younger Cassini severely criticized these conclusions of Blanchini; and tried to show that in the time which Blanchini had computed as requisite for one revolution, the planet had really made 25; and this he said would accord with his father's calculations. Afterwards Schroeter, watching what he believed to be a mountain, concluded that the time of the planet's rotation is 23 hours and 21 minutes. In 1842 De Vico of Rome maintained that he had rediscovered the markings which Blanchini 116 years before had spoken of; and from these markings De Vico deduced the planet's axial time as 23 hours and 21 minutes. On the other hand, the great English astronomer Herschel declared he was never able to see any such permanent markings on the disk of Venus as those older astronomers had spoken of; and he believed that whatever irregularities or prominences may have been seen by them on the face of the planet, were due to clouds or other such atmospheric phenomena. Newcomb thinks that the best astronomers of to-day are inclined to agree with Herschel, though on different grounds. No permanent spot nor regular marking has ever been detected with the great Washington telescope. With such powerful instruments as are at command to-day, it is believed that if the conclusions of these old astronomers, concerning the axial rotation of Venus, were true, there would be little or no difficulty in verifying them; but as with all telescopic improvement the modern astronomer is unable to find for a certainty any such phenomena on the planet as they said they found, it is held that our knowledge concerning the axial rotation of Venus is anything but certain; although it is often given as being 23 hours, 21 minutes, and 22 seconds, as maintained by De Vico of Rome in 1842. On the other hand, Vogel insisted in 1873 that the atmospheric conditions of the planet are such as to make it impossible to determine its axial rotation with anything like certainty. It is quite generally held to-day that, like Mercury, so Venus keeps the same side always turned towards the sun; that its axial rotation is only concurrent with its siderial; that one hemisphere is in an eternal summer, and the other in an eternal winter. This fact, it seems, makes impossible the existence on its surface of a physical condition similar to that on our earth.

When in its orbit, near inferior conjunction, a crescent of light extends over more than 180°; and this is held to be impossible, were it not for an existing atmosphere producing refraction. Newcomb says: "There is no known way in which the sun can illuminate so much more than half of venus as to permit a complete circle of light to be seen, except by the refraction of an atmosphere." It is said that this fact was first noticed by David Rittenhouse of Philadelphia, when observing on June 3rd a transit of Venus. Mädler found in 1849 that this crescent extended over more than half a circle, and computed the refractive power of an atmosphere necessary to produce this as being greater than that of the earth; or as requiring a horizontal refraction of 44″, that of the earth being only 34″. The next important observation was made by Lyman of Yale College, in 1866. It was a favorable time, as the inferior conjunction of the planet occurred when it was very near its ascending node, making its angular distance from the sun less than it had been at any time before during the present century, the planet thus passing near to a line drawn from the earth to the sun. Lyman said he saw not merely a thin crescent, but a fine circle of light extending around the planet, the side farthest from the sun having an extremely thin thread of light going all around it. As this was the first time that this circle of light had been seen extending all around the planet, since the days of Rittenhouse, this observation of Lyman is considered a great honor to the United States.

From spectroscopic examination of solar light reflected from the planet, we get nothing new; no new lines are found, but some lines are believed to be a little stronger. This shows that the atmosphere of Venus has little selective power on the solar ray as it passes through it; that the gases known to have such selection are largely absent from the atmosphere of Venus.

A phosphorescent light is said to have been seen by certain astronomers on the dark disk of Venus, very similar to that seen on the moon, when people say, "The old moon is in the new moon's arms"; but since this is said to have been seen by day, when it should have been more easily seen by night, astronomers generally have little faith in the reality of such appearance, believing it to have been due to optical illusion.

The planet looks brightest when at that part in its orbit between the points of greatest elongation and that of inferior conjunction. It is here that its angle of elongation equals about 40°. At such time the planet is visible all day to those who know just where to look for it.

The density of Venus is to that of Earth as 85 to 100; its mass as 769 to 1000; its volume as 880 to 1000; its specific gravity as 48 to 56; its diameter as 7700 to 7918. The earth is the larger planet, but the differences are slight.

The orbit of Venus is inclined to the plane of the ecliptic only 3½°. The sun passes its nodes in June and December; and therefore all transits of the planet occur during these months.

By some it is held that Venus was known to the ancients under the names of Hesperus and Phosphorus, the evening and morning star; but others insist that these names denoted different bodies before the rise of exact astronomy; that not until the astronomer had carefully observed the motions of Venus, and seen it disappear in the sun's rays so soon to emerge again, was it certainly known that Hesperus and Phosphorus were one and the same.

It was believed by Cassini, Short, and many others that Venus had a satellite, and one astronomer went so far as to compute the orbit of the supposititious body; but by others the orbit computed was declared to be such as no satellite could possibly revolve in, unless governed by a primary ten times larger than Venus.

The passage of Venus across the sun's disk is called a transit. This can occur near a node only. If Venus moved in the plane of the ecliptic, it is plain there would be a transit at every inferior conjunction; but since its orbit is a little inclined to the ecliptic, a transit does not occur at every conjunction, but only when the inferior conjunction happens near the node, or near the point where the planet passes from one side of the ecliptic to the other. That a transit take place, the latitude of the planet, that is its distance south or north of the ecliptic, must be less than the angular diameter of the sun, that is, less than 16′. The earth being at the longitudes of the nodes on June 6th and December 7th, only of each year, it follows that transits of Venus, if they occur at all, must occur very near these times. Transits occur quite regularly. The motions of the earth and Venus are such that the latter makes 13 revolutions while the former makes 8. At each node there may be one transit or two, according to the planet's distance from the node. These transits occur at regular intervals. During every interval of 243 years, the same phenomena are repeated, such variations as occur being caused by the secular accelerations of Venus and the earth.

When a body coming between the earth and the sun is seen to pass across the sun's disk, without intercepting much of his light, the body is said to be in transit. We speak of an eclipse of the sun by the moon because the nearness of the moon to us enables it to cut off or intercept very much of the sun's light; but we say a transit of Venus, because the distance of that body is so great that it can not cut off to any great extent the solar rays. In a transit the body passes over the sun's disk as a black spot.

Transits of Venus have been carefully watched for the purpose of determining the sun's parallax, and therefore his distance from the earth. Godfrey says we have in the observation of these transits the most accurate method for the determination of the sun's parallax; but Newcomb doubts the truth of this assertion, and states his opinion that the sun's parallax is more accurately determined by the gravitation method, and by the velocity of light. These methods are too recondite for full exposition in a work of this character; and the reader must be referred to special works on the subject. The transit of Venus remains the most celebrated method for determining the solar parallax, whether some other method, such as that to which Newcomb refers, be more exact or not.

The first transit of Venus we have any account of was observed by Horrox, an English clergyman, who was at that time an enthusiastic astronomical observer; and it is to an English astronomer also, the celebrated Halley, to whom the world gives the honor of discovering the method of determining solar parallax in the transit of Venus.

One revolution of Venus is made in 224.700787 days, and one of the earth in 365.256381. The least common multiple of these quantities will give the number of years between two successive conjunctions of the planet Venus at the same point in space. All intermediate conjunctions will necessarily occur at other points in its orbit. The quantities 8,105,112,235 and 243, multiplied by the number of days in a year, are very near multiples of the times of the synodal revolutions of Venus and the earth; and therefore at one or another of these periods a transit of Venus is sure to occur. The number 243, multiplied by the number of days in a year, is almost an exact common multiple; and it is therefore held that in 243 years the same phenomena are always repeated.

VENUS

Diameter 7700 miles. Mean distance from the sun 67,200,000 miles.

Siderial priod 224.7008 days. Orbital velocity per second 21.9 miles.

Mass 0.78, earth being 1. Volume 0.920, earth being 1.

Density 0.86, earth being 1. Specific gravity 4.85.

Superficial gravity 0.83, earth being 1. Axial rotation 225 days; synodic period 584 days.

CHAPTER IV

PLANETS CONTINUED

MARS

OUR next neighbor in space is Mars. This planet, being farther from the sun than is the earth, is less attracted to the sun's centre than is the latter. If we represent the distance the earth falls through space in any definite period of time by the square of 1.52, Mars during the same period will fall the square of 1 only.

The earth in its orbit around the sun passes every day 59′ 8″.3, while Mars passes during the same time only 31′ 26″.7. It follows therefore that while Earth's year is 365.256 days, that of Mars is 686.98.

The diameter of Mars is not much more than one-half that of the earth, being about 4211 miles; its surface about one-fourth that of the earth, and its density seventy-three one-hundredths; its mass about one-ninth. Its period of rotation around the sun is 1 year, 321 days, 17 hours, 30 minutes, 41 seconds.

Mars, being outside the earth, is nearer us when in opposition by the diameter of the earth's orbit than when in conjunction. In opposition the mean distance of the planet from us is about forty-eight million miles; but in conjunction it is not less than two hundred and thirty-three million. But because of the elliptical form of the orbits of the earth and Mars, or their eccentricities, Mars may come within thirty-four million miles to the earth, and may recede no less than two hundred and forty-seven million from us. The eccentricity of Mars' orbit is 0.0932168, this being, with the exception of that of Mercury's, the greatest of any of the planetary orbits.

As Mars and Earth do not move at the same rate in their orbits, it is evident they must pass and repass each other. In the case of Venus and Earth, it was Venus that passed us; but in the case of Earth and Mars, it is we that pass it. How long it must take the earth to overtake Mars again, when once they are side by side, as it were, in space, we may find out thus. Let us represent by x the number of days Earth will be coming up to him again, when once she has quitted his side. The daily angular motion of Mars equals 360 divided by 687, and that of Earth 360 divided by 365. Therefore we have the equation $687x$ minus $365x$ equals 360 multiplied by 687. Solving this, we find for the value of x, 788. This time is about equal to 2 years and 50 days. If, therefore, after conjunction or opposition we wish to know when the same will occur again, we have only to add this time to the date of the last occurrence, and we shall have the time when next it will occur.

Mars, when near opposition, is easily recognized by his fiery red light. Because of this redness he has been called the god of war. When in opposition Mars rises of course in the east when the sun is setting in the west. At such times his brilliancy always greatly exceeds that of an ordinary star of the first magnitude.

The perihelion of Mars is in the same longitude as the earth is in August. It is about this time the earth is in aphelion. Therefore if opposition of Mars occur at this time, Earth and Mars are very near each other, being only about 35,000,000 miles apart, and the planet will shine with about four times the brightness with which it shines when opposition occurs at its aphelion; for it is then about 62,000,000 miles from the earth. It is said that the opposition which occurred September 5th, 1877, was most remarkable, occurring just nine days after the planet had passed its perihelion. It was at this time that the two satellites of Mars were discovered. This memorable discovery was made by Professor Asaph Hall, at Washington University. He was observing the heavens in the neighborhood of Mars, with the great equatorial telescope of that university, when he chanced to see, a little east of the planet, a small body which looked like a little globe. Just then the coming of cloudy weather prevented him from continuing his observation; but on turning his instrument toward the planet Mars, on the night of the 16th, he soon saw again the little body he had seen on the previous evening. After he had followed the spot for a couple of hours, he became convinced that it was a small satellite of the planet. Still the astronomer feared he might have been mistaken, that the spot might have been some small body which happened in that neighborhood; so he postponed making any announcement. Making calculations of the probable period of such a body from its observed elongation, he came to the conclusion that if the discovered body was really a satellite of Mars, it ought to show itself again in about 29 hours. His calculation proved to be correct enough; for at four o'clock in the morning of August 18th, it was seen to emerge from the planet. He was now certain enough that he had discovered a satellite of Mars. His delight was not to cease on this, great as the honor was; for it was while observing at this time the little body emerging from the planet, that he saw another body much nearer the planet still. This in like manner he soon proved to be another satellite. In a few days no room for doubt remained. He announced his discovery, and it was soon fully confirmed by Pickering and Clark. These little worlds are truly wonderful because of their proximity to the parent globe. The distance of the inner one is less than 4000 miles from Mars' surface, in other words only about as far as the earth's centre is from us. The outer satellite revolves around Mars in 30 hours and 18 minutes, and the inner one in 7 hours and 39 minutes. The diameter of the outer one has been calculated as being somewhere between 5 and 10 miles, and that of the inner one as being between 10 and 40.

These bodies must appear most wonderful to the inhabitants of Mars; for with a telescope such as we possess they could perceive on the surface of the inner satellite objects no larger than many animals we have with us on earth. It perhaps were not impossible for them to perceive a man, if such existed on the inner satellite. How wonderful must these little worlds appear! To think of a celestial body whirling over our heads through space so fast as to pass all around our globe in a few hours! It would be an awful sight indeed.

Mars is a planet whose axial rotation astronomers feel certain of. Procter has given its period of axial rotation as 24 hours, 37 minutes, 22.73 seconds; and this is considered almost absolutely correct.

Mars has been such a favorite object that many astronomers have mapped its surface, perhaps too confidently. Around the poles of the planet a brilliant whiteness is visible, similar to what our poles must show to the inhabitants of Mars. As measured by Arago, the light reflected to us from these white spots, is twice as intense as that reflected from any other part of the planet. On the equatorial parts some profess to see dark-red and greenish portions, as if caused by land and water. Many maintain that these dark spots present constant form, and keep their relative positions. Others maintain that artificial canals evidently constructed for irrigation purposes can be plainly made out. Indeed, some astronomers affirm that if our earth were seen from Mars, with instruments equal to our own, it would appear as Mars does to us. According to the opinion of these investigators it is most probable that the surface of Mars is diversified by land and water, oceans and continents, and that the planet has an atmosphere quite similar to our own. How wonderful, therefore, to think that on the planet Mars there may be investigators, teachers, lecturers, ministers, legislators, astronomers, and even philosophers, moved by feelings and desires similar to our own! But as in many other instances it is more wonderful that the wonder should not be real than that it should be, so in this case: it would certainly be far more wonderful that this little earth of ours should be the only birth-place or scene of conscious activity, sorrows, pains, joys, and pleasures, than that other worlds, not at all unlike our own, should also be the scene of similar activities. We must not fail, however, to state that there are not wanting astronomers of very high reputation who deny that Mars is so much like the earth in its physical condition, and doubt the fitness of the planet for life and intelligent activity as manifested with us. Such conflicting opinions being held by the highest authorities, we certainly may well reserve our judgment.

The plane of Mars' orbit is more inclined to that of his equator than is the plane of the earth's orbit to that of her equator, the inclination of the former being about 27°, while that of the latter is about 23½°. Because of this the changes in Mars' seasons must be much more extreme than the changes of the seasons with us.

The dimensions of Mars' satellites are so small that it is found impossible to measure their diameters with any instruments as yet manufactured. Their diameters are computed by the amount and intensity of the light these bodies give us, as compared to that given by the primary planet. When in opposition, at the most favorable point in its orbit, Mars is said by Zöllner to be three magnitudes brighter than a star of the first magnitude. The magnitude of the outer satellite is set down as about the eleventh or twelfth. This would make a difference of from fourteen to fifteen magnitudes between Mars and his outer satellite. Since the order of magnitude increases in a geometrical ratio, the ratio being about 2½, we find by this reasoning that Mars gives us from 200,000 to 500,000 times more light than his outer satellite. The diameter of the outer one is supposed to be five or six miles, and that of the inner one about seven. The name of the outer one is Deimos; that of the inner one, Phobos. The outer satellite revolves around Mars in 30 hours 18 minutes; the inner one, in 7 hours 39 minutes. The outer one is distant from the primary body bout 14,600 miles; the inner one, about 5800. The orbits of these satellites appear circular, and to be in the plane of their primary's equator.

As superior planets do not move in their orbits with angular motion equal to that of inferior planets, they have what is called retrograde motion; in other words, they appear to move in a direction contrary to that of the earth. This can present no difficulty when we remember we witness such movements every day of our life. We take the train for down town, and on our way overtake a freight-train. Looking out of the window at the latter, as we are passing it, it will appear to be moving in a direction opposite to that in which we are moving; and this is all there is to the retrograde motion of the planets. The earth moving round the sun passes over more degrees in a given time than a superior planet moving around the same common centre, and in the same direction; and the consequence of this is similar to that just mentioned in the passing of the trains: although moving in the same direction, the superior planet will appear to be moving in an opposite one.

The distance of a superior planet from us or from the sun may be determined by measuring the angles of elongation. There must be two observations separated in time equal to the superior planet's period. At the second observation the earth will be at a different point in her orbit from that it occupied at the first observation; and these two points will be separated by the difference between two revolutions of the earth and one of Mars. Mars' period is 687 days, and twice Earth's period is 730½. The difference is 43½. This difference being days, if we multiply it by the number of degrees the earth moves in her orbit in one day, we shall have the number of degrees separating the earth at the second observation from the point it occupied at the first. This being known, we shall find that in the quadrilateral formed by drawing lines connecting Earth, Sun and Mars at both observations, we shall have all the needed data for solving it, and therefore for determining the planet's distance. Similar methods may be used for determining the distance of an inferior planet; but it is needless to say that astronomers do not depend on this method, finding it much more expeditious and more exact to base their calculations on the general law: the square of a planet's time is as the cube of its distance.

MARS

Siderial period 686.9505 days; Axial rotation 24 h 37 m 22.67s.;

Diameter 0.534, Earth being 1; Volume 0.152, Earth being 1;

Mass 0.107, Earth being 1; Density 0.72, Earth being 1;

Superficial gravity 0.38; Orbital velocity 15 miles a second; Mean distance from the sun 141,500,000 miles; synodic period 780 days.

THE PLANETOIDS

It was at the end of the last century that Bode, of Berlin, announced the discovery of a certain law governing the distances of the planets from the sun. He said that if to each of the numbers 0, 3, 6, 12, 24, 48, 96, 192, 384 we add 4, we shall have 4, 7, 10, 16, 28, 52, 100, 196, 388; and that this series of numbers expresses sufficiently exactly the relative distances of the planets. It is true enough that for each of these quantities, with the exception of the fifth, there was indicated a known planet; and being so nearly true for all the then known planets, it was thought that it must be true for a planet that should answer to the fifth number, and astronomers labored to find it. Mercury was represented by the figure 4, that is as being four units distant from the sun; Venus was represented by the figure 7, that is as being seven units distant from the sun; Earth was represented by the figure 10, that is as being ten units distant from the sun; Mars was represented by 16, that is as being sixteen units distant from the sun; but 28 stood as representing no known planet. After this the numbers were roughly true for all the other known planets. Such a correspondence it was thought could not be accidental, or of mere coincidence; it was rather believed that there must be somewhere between Mars and Jupiter an undiscovered planet answering to the quantity 28. So strong was the belief in Bode's law that a systematic search was instituted. On January 1st, 1801, Piazzi discovered one, which in due time he called Ceres; and in March of the following year Olbers discovered another, and named it Pallas. He then suggested the idea that the two little bodies might have had a common origin, and thought that many others might be discovered, all being fragments of one and the same original body. In 1804, Harding of Lilienthal found a third planetoid; and in 1807, Olbers found a fourth. They named these Juno and Vesta. In December, 1845, Hencke of Driessen found another similar body; and from this date there have been continual discoveries of new planetoids belonging to the same group, all moving around the sun in the space between Mars and Jupiter. Since the year 1847 there has been one or more of these little bodies discovered on the average every year. In the year 1892 no less than 28 were added to the then known number; and up to the present time not less than 600 have been discovered in all.

Piazzi and Olbers held that if these little bodies were fragments of a common planet, their orbits should have a common point of intersection; that is, that in passing around the sun they should all pass through one common point. At first this was supposed to be a necessary result of physical law; but it was afterwards held, and is to-day, that owing to secular changes produced by the interaction of all the planetoids, their orbits would slowly change, even if they had had a common origin, and that in time no trace of a common origin would be found. It may be said that the nebular hypothesis offers a reasonable theory for the origin of the planetoids.

These bodies are very small. The largest are Ceres and Vesta, whose diameters lie somewhere between 200 and 400 miles. Some have diameters from 20 to 40 miles; others are too small for measurement. How many there may be yet undiscovered is totally unknown; nor is it considered a question of importance. Indeed, one astronomer said that if an observer should by chance find another, he should let it go and come without molestation; and perhaps this is sensible advice.

These bodies are remarkable for their great eccentricites. With the exception of the planet Mercury all the planets have small eccentricites, none having an eccentricity equal to one-tenth of the radius of its orbit; but in the case of the planetoids the eccentricities of some of them exceed one-fourth of the radii of their orbits. None of these planetoids of the inner group moves in an orbit less than thirty or forty million miles distant from that of Mars; and none of the outer group in an orbit less than fifty million miles distant from that of Jupiter. To show the great eccentricites of some of the orbits of these little bodies, it may suffice to mention that of Aethra, a planetoid discovered by Professor Watson, of Ann Arbor, in 1873. This little planet at one part of its orbit is only 1.61 astronomical units distant from the sun; while at another it is no less than 3.59. Two or three others are known to be about twice as far from the sun at aphelion as at perihelion.

These bodies are also remarkable for the great inclination of their orbits to the plane of the ecliptic; in some cases, in that of Pallas for instance, this inclination is not less than 34°; several others have inclinations exceeding 20°.

JUPITER

We are now come to the king of planets, to a second sun, a body ruling a kingdom not altogether unlike that of the mighty parent sun himself. Jupiter was no more excellent among the immortal gods than this planet among the immortal worlds ruling the empyrean spheres. Even as early as the time of Galileo this great planet was thought to represent a miniature solar system. It is said that this view was in some measure the cause which led to the discovery of the Copernican theory. Jupiter has nine satellites. Four were discovered by Simon Marius, Dec. 29, 1609. Five more have since been found,—the fifth or innermost by Barnard in 1892; a sixth and a seventh, both outer planets, by Perrine in 1905. The sixth, seventh, eighth, and ninth are faint bodies too small for definite measurement, and were discovered by the means of photography.

If we call the earth's distance from the sun 1 or unity, then the distance of Jupiter will be 5.202767. Its diameter is about eleven times that of the earth, and one-twelfth that of the sun. In other words, his diameter is about 87,000 miles; his volume is not less therefore than 1450 times that of the earth. His specific gravity being no more than 1.378, or about one-fourth that of the earth, his mass is only a little more than 311 times that of our globe. The sun is about 326,800 times heavier than the earth, but only about 1047.88 times heavier than Jupiter. If we put the earth as unity, Jupiter has 311.86 units of mass.

Jupiter revolves very rapidly on his axis, making a complete revolution in the very short time of 9 hours, 50 minutes, 20 seconds. Considering the circumference of this mighty planet as 270,286 miles, this gives us for his axial rotation a velocity of 7.567 miles a second. Taking the distance of the planet from the sun at 480,000,000 miles, the circumference of his orbit must be about 3,000,000,000 miles. This great distance Jupiter travels in 11.86 years; for this is his periodic time. We thus find that his orbital velocity is 8.06 miles a second, this being but little more than that of his axial rotation.

The eccentricity of Jupiter's orbit is 0.0482519. This makes his distance from the sun at aphelion about forty-six million miles greater than when at perihelion. The actual distance of the planet from the sun, therefore, ranges from about 457 to 503 million miles.

Jupiter is the brightest body in our heavens with the exception of Venus; and the best time to see him is, of course, when he is in opposition. Since he moves in his orbit about 30 degrees each year, it follows that his opposition is about one month later every year, the earth taking this much of time to overtake him. If we wish to know the exact time of his next opposition after the present, we proceed thus: Letting x equal the number of days the earth will be overtaking Jupiter, and knowing the orbital velocity of each of the two planets, we have $360x$ divided by 365.25, minus $360x$ divided by 365.25 times 11.86, equal 360. Solving we have for the value of x 397.5. This shows that the earth will come up again with Jupiter in 397.5 days.

Not only is the Jovian monarchy a miniature solar system; but Jove himself is, in some degree, like the sun in its constitution. The density of the sun is 1.111, water being unity, and that of Jupiter is 1.378. Taking the earth's density as unity, that of the sun is 0.2552, and that of Jupiter 0.2435. Thus there is but little difference between the density of the sun and that of Jupiter; each has about one-fourth the density of the earth.

It used to be said that Jupiter had two very broad belts extending around the north and south sides of its equator. It is now believed that these so-called belts consist in reality of great numbers of stratified cloud-like appearances of the most variegated forms. So fleeting are these forms that the face of the planet appears to undergo great changes in a single day. When a small telescope is used, these cloud-like forms appear as two broad belts; and this is the reason for the old-time description. From the surface appearance of Jupiter it is believed that what we see through the telescope is not a solid nucleus; but sun-like clouds or vapors which cover the whole body of the planet, and extend down to great depths. It is this envelope that is seen when we look at Jupiter through the telescope; and this envelope is so deep and dense that light can not penetrate. These dense and stratified clouds are said to arrange themselves in zones parallel to the equator; and inasmuch as they appear different in different latitudes, they present some likeness to our zones and clouds. It is considered certain that Jupiter has a very dense and deep atmosphere. The centre of the planet is brighter than its edges, perhaps two or three times as bright. We have a striking proof of this at the time of the transits of its satellites over its disk. When first the satellite enters on the disk of the planet, it appears as a bright spot, thus showing that it is brighter than that part of the planet; but as it approaches the centre, it seems to grow darker and darker, until finally arriving at the centre of the planet's disk, the satellite appears as a black spot on the bright background of the planet, showing clearly enough that it is not so bright as this part of the planet. It is thought, however, that this difference may have some other cause than that of which we are speaking: near the edge much of the planet's light may be absorbed by the greater depth of clouds and vapors through which the light at that point must pass in coming to us.

Another striking likeness of Jupiter to the sun is found in the fact that the planet shines partly by his own light; that is, the temperature of Jupiter is not as yet below the point of radiation. So evident is Jupiter's light-radiation that it was once believed that it gave more light than it received from the sun. Zöllner calculated that it is necessary for Jupiter to reflect not less than sixty-two per cent of the light it receives from the sun, in order to account for its brightness. But if sixty-two percent is to be its average reflecting power, then in the words of Newcomb, "the reflecting power of its brighter portions must be much greater; in fact they are so bright that they must shine partly by their own light, unless they reflect a disproportionate share of the sunlight back in the direction of the earth and sun." On the other hand, it is certain that the quantity of light emitted by Jupiter can not be very much, or its satellites would shine when in its shadow by reflecting the planet's light, while now they are seen to totally disappear into the blackness its shadow creates. The opinion, however, is pretty well established that at least the brighter portions of Jupiter do emit light or are self-luminous.

Jupiter is said to present another likeness to the sun because also of the great activity evidenced in its centre; the only way to account for this being a very high internal temperature. It is thought that the changes we witness can not be produced by the sun's rays, since the distance of Jupiter is so great that it receives only one-twenty-fifth or one-thirtieth of the light and heat the earth receives. Taking all into consideration, it is the received opinion that Jupiter has not as yet any solid crust such as the earth has; that it has an interior at a temperature perhaps of white heat. From this inner seat of fire, either gaseous or semi-solid, the vapors which arise would not be greatly unlike those that are known to arise from the sun, and would at first be self-luminous, becoming less so as they approach the surface of the planet, and finally losing their luminosity after exposure for a time to the conditions in which the outer part of the planet finds itself. This would account for the bright spots which at times are seen on the planet's surface; and then again for the dark spots which seem to take their places.

When we think of a body so large, so stupendous, as Jupiter, and of the many worlds over which its sway extends, we must admit that the planet is well named.

The orbit of Jupiter is almost coincident with the plane of the ecliptic, being inclined to it only 1° 19′; the eccentricity of its orbit is very great, being one-twentieth of its diameter, or three times as great as that of the earth's orbit. The planet's equator is inclined to the plane of its orbit a little more than 3°, giving but little cause for any perceptible change in the seasons.

Jupiter rules nine moons or satellites, which revolve in orbits almost circular, and whose planes are but little inclined either to the orbit of the planet or to the ecliptic. They are called first, second, third, fourth, etc., counting from the planet outward. It is said that there is a relation between the first three of Jupiter's satellites that has no known similarity anywhere in the solar system elsewhere.

If to the mean motion of the first satellite you add twice the mean motion of the third, it will give you exactly three times the mean motion of the second. Also if to the mean longitude of the first satellite you add twice the mean longitude of the third, and subtract three times the mean longitude of the second, you will find the difference is always 180°. LaPlace said, granting such relation to exist, that there would arise as a result of all the interacting forces of Jupiter and its satellites, a resultant force which would keep the satellites in this relation forever.

The diameter of the first satellite is 2500 miles, its distance from Jupiter 261,000 miles, and its periodic time 1 day, 18 hours, 27 minutes, 34 seconds; the diameter of the second is 2100 miles, its distance from the planet 415,000 miles, and its periodic time 3 days, 13 hours, 13 minutes, 42 seconds; the diameter of the third is 3600 miles, its distance from Jupiter 664,000 miles, and its periodic time 7 days, 3 hours, 42 minutes, 33.4 seconds; the diameter of the fourth is 3000 miles, its distance 1,167,000, and its periodic time 16 days, 16 hours, 32 minutes, 11.2 seconds; the diameter of the fifth is 100 miles, its distance from the planet 112,000 miles, and its periodic time 11 hours, 57 minutes and 23 seconds. A sixth satellite has been found having a periodic time of 242 days 12 hours, and a seventh having a period of 265 days. The sixth and seventh satellites are very faint bodies, and are too small for definite measurement.

Jupiter, as we have said, is the largest planet in the solar system; and he therefore casts a big shadow as he rolls along in the dread silence. Because of the nearness of the satellites, and the small inclination of the planes of their orbits to that of Jupiter, they are subject to an eclipse caused by Jupiter coming between them and the sun. It was through this eclipse that a method was found for measuring the velocity of light. When in opposition Jupiter is nearer the earth by the whole diameter of the earth's orbit than when in conjunction. By much labor it has been found that light requires 998 seconds to cross the earth's orbit. Thus Jupiter has rendered us a great service in giving us the means for determining this question; not that it has not been determined by other methods, but because in this we have the means of testing the accuracy of other methods.

JUPITER

Distance from the sun 483,300,000; siderial period 4332.58 days; orbital velocity 8.1 miles a second;

Diameter 86,500 miles; volume 1309, Earth being 1; density 0.24, Earth being 1;

Mass 316, Earth being 1; axial rotation 9 hours 55 minutes; surface gravity 2.65; synodic period 399 days.

CHAPTER V

PLANETS CONTINUED

SATURN

THE next planet for our consideration is Saturn, than which nothing more wonderful or unique is in the heavens above or in the earth beneath. This phenomenal globe is distant from the sun 9.54 units, or 886,000,000 miles. Its orbital eccentricity is 0.056; the planet therefore is 50,000,000 miles farther from the sun in one part of its orbit than in another. It is nearest to us at a December opposition, being then about 744,000,000 miles distant; and farthest from us at a May conjunction, when it is about 1028 million miles from us. Its apparent angular diameter varies from 20″ to 14″; but its distance is so great that this difference affects but little its apparent brightness. Saturn is 10,759.22 of our days making one revolution around the sun; but great as this tour is, the sun forces the planet to keep marching on. Its synodic period is 378 days. Its surface is about 82 times that of our earth, and its volume about 760 times. Its density is the least of any planet, being about one-eighth only of the density of the earth, and its mass about 95 times that of our planet. Like Jupiter this planet revolves very rapidly on its axis, making one revolution in 10 hours 14 minutes 24 seconds. Its orbital velocity is less even than Jupiter's, being only 6 miles a second; and its orbit is inclined to the plane of the ecliptic 2° 29′ 40″. The plane of its equator is more inclined to that of its orbit than in the case of the earth, the inclination being no less than 26° 49′, an inclination exceeding that of any other planet.

So great is the distance of this wonderful planet that if we were to go to it on a railroad car at the rate of forty miles an hour, we should be about 2135 years going the journey; and if we occupied a Pullman car, and paid two dollars a night for a berth, it would cost us $1,606,000 for sleeping privileges. If those that covet the earth, and corner the markets, could only extend their power to the sun's outlying spheres, how happy they would be for a time! But even then it would be but misused energy, man's dominion being for such brief duration, and himself but a shadow.

The great axial velocity of Saturn would naturally tend to shorten the diameter of its poles, especially when we consider the little density of the planet. Herschel set down this shortening, in 1776, as 10/104, and Besel after observation extending over three years, as 10/102.

The belts of Saturn are less distinct than those of Jupiter, and are less subject to variation. Around the equator there is a bright, shining zone, and at each pole a greenish cap. Saturn's spectrum is very like Jupiter's; and the two planets are probably in very similar states. No evidence of aqueous vapor has been found in Saturn's spectrum; but there are unknown bands in the red and orange similar to those found in the case of Jupiter.

Like Jupiter's so Saturn's atmosphere is deep and dense. The whole planet is probably as yet in a gaseous condition.

The most remarkable phenomenon in the case of Saturn is the ring-system. These have long been observed, and were a great puzzle to the astronomers of the seventeenth century. It is said that Huygens first guessed that they were rings. These rings are three. The outer one is 11,500 miles broad, and is separated from the next inner one by a space of 2400 miles; then comes the inner ring, which is 17,500 miles broad, and is not perceptibly separated from the innermost ring, which is 10,000 miles broad. Neither of the rings is thought to be more than 100 miles thick. The outer and middle rings are much brighter than the inside one.

The constitution of these rings used to puzzle every one. In the United States, Pierce and Bond investigating their nature came to the conclusion that they could not be solid, and held they were fluid; although Bond had to find in the satellites of Saturn the support that was thought necessary to the stability of the Saturnian system. It was left for Clerk Maxwell, of England, in 1856, to demonstrate that these rings could not be fluid nor solid; and to show that they must be composed of myriads of meteors too small to be seen, and too close together for seeing any space between them. This theory offers a reasonable explanation for the maintenance of equilibrium, and is the one universally received to-day. In reference to this William Meyer of Berlin says: "It may at first glance seem improbable that the great contours of this ring-shaped cloud of dust have nevertheless for centuries remained the same. But it has recently been shown by exact calculation that the outlines of the rings are wholly determined by the attraction exerted by the satellites, and that indeed an entirely formless cloud of stones, if it were precipitated about Saturn, with the requisite velocity, and at the same distance the rings now occupy, would necessarily assume in every detail the exact form that the rings at present possess."

Of these rings it may be said that it is quite possible they are planets in the course of formation; that in due time Saturn will have as many more satellites added to its system as there are now rings, and possibly more.

There are ten satellites now known to belong to Saturn. Five of these were known in the seventeenth century, two were discovered in the eighteenth, two in the nineteenth, and one in the twentieth century. These are their names in the order of their distance from the planet: Mimas, 117,000 miles distant, diameter 750 miles, siderial period 22 hours 37 minutes 6 seconds; Enceladus, distant 157,000 miles, diameter 800, siderial period 1 day 8 hours 53 minutes 7 seconds: Tethys, distance 186,000 miles, diameter 1100, siderial period 1 day 21 hours 18 minutes 26 seconds; Dione, distance 238,000 miles, diameter 1200, siderial period 2 days 17 hours 41 minutes 9 seconds; Rhea, distance 332,000 miles, diameter 1500, siderial period 4 days 12 hours 25 minutes 11 seconds; Titan, distance 771,000 miles, diameter 3000, siderial period 15 days 22 hours 41 minutes 23 seconds; Themis, distance 906,000 miles, diameter 40, siderial period 20 days 20 hours 24 minutes; Hyperion, distance 934,000 miles, diameter 500, siderial period 21 days 6 hours 39 minutes 37 seconds; Iapetus, distance 2,225,000 miles, diameter 2000, siderial period 79 days 7 hours 54 minutes 17 seconds; Phoebe, distance 8,110,000 miles, diameter 40, siderial period 550 days 10 hours 33 minutes 36 seconds.

The inside five satellites have circular orbits. The largest satellite has a mass such that it would take 4600 of it to equal that of the primary planet. It is not impossible at times to observe eclipses and transits of some of these small bodies; but it is necessary to use large telescopic power.

When one considers the origin and future of Saturn's rings, he can not help thinking of the moon, when she stood in embryo, a nebulous belt girding the mother Earth, how gradually that belt parted as a newly born child from its mother, and finally condensed into an independent orb. The theory that the moon some time or other was vomited forth or shot up by the earth, as a result of some violent explosion, does not appear a satisfactory one.

SATURN

Distance from the sun 886,000,000 miles; diameter 73,000;
Siderial period 10,759.22 days; axial rotation 10 hours 14 minutes 24 seconds;
Orbital velocity 6 miles a second; synodal period 378 days;
Surface 82, Earth being 1; density .13, Earth being 1;
Volume 760, Earth being 1; Mass 94.9, Earth being 1;
Surface gravity 1.18.

URANUS

In our passage from the sun outward, Uranus is the next planet we reach. This body was unknown as a planet to the early astronomers; for although it had been several times observed, it was not until 1781 that Sir William Herschel, while examining a small group of stars in Gemini, noticed that the disk of one of them increased very considerably under magnifying powers of 460 and 932; and that its luminous intensity decreased as the larger magnifying powers were used. These facts he knew were not characteristic of the fixed stars.

It is said that on the first discovery of Uranus by Herschel, he thought it was a comet; but by the united labors of Lexell, LaPlace, Saron, and Mechain, the true character of the body was finally recognized, and its orbit determined. Thus another planet was added to the known number of bodies revolving around the sun. The portion of space known to have been ruled over by the sun before the discovery of Uranus by Herschel, was of no mean dimensions; but by the discovery of this planet, the known empire of the sun was extended about twice as far as before.

The discovery of Uranus gave great enthusiasm to astronomers, and filled them with fresh zeal. It was something really new; for up to this time no new planet had been added to the known number for thousands of years. It was just about 100 years since a heavenly body of any kind, except comets, had been added to the known number. It was in 1684 that the third satellite of Saturn had been discovered.

Herschel gave the planet the name of Georgium Sidus; and it was known by this name in England for more than sixty years. Leland thought that the planet should be named Herschel in honor of the discoverer; but this name was considered too personal. It was finally and generally agreed, being proposed by Bode, that the planet should be called Uranus, and by this name it is known to-day.

Uranus is so far distant from the earth that it is not generally visible to the naked eye. At its nearest approach to the sun it appears as a star of the sixth magnitude. At such time a person with very clear vision is able to see it. Its apparent diameter is 3.9″; but its true diameter is about 31,000 miles.

Uranus does not present the mottled or belted appearance of Jupiter, but a sea-green hue with obscure markings. The great distance, however, of this planet makes it impossible to observe it as the nearer members of the solar system are observed; and much of what is said about its physical appearance is largely guesswork.

The shortness of human life, and the immortal nature of the worlds that roll over us, are quite well illustrated in the case of the planet Uranus. Its great discoverer has long ago been consigned to mother Earth; but this far-off planet in the meantime has scarcely added one of its years to its life, scarcely moved more than one revolution in its distant race-course. With Herschel a single one of our years would increase the grey hairs on his head, and the passing of a single day add to his consciousness of failing strength; but eternity seems to be stamped on Uranus, which in a year moves in its orbit scarcely four and a half degrees.

The orbit of this planet is very nearly in the plane of the ecliptic, being inclined to it less than one degree, in exact figures, 46′ 20.92″; it is also quite circular, having an eccentricity of only .0463592, about one-half that of Mars' orbit.

The mean distance of Uranus from the sun is about 1,780 million miles. We speak of the sun as being at an almost unimaginable distance from us; but in the case of Uranus we have one of the sun's family under complete control at a distance more than nineteen times that of the sun. We write these numbers, indicating them by symbols; but of their true significance it is altogether beyond the mind of man to imagine. How limited after all man's thoughts! How everywhere bounded the field of his operations! Most of us would think it a grand piece of good fortune to be able to travel around the world; but what is this compared to the vast intervening space which separates the earth and Uranus. Should we travel around the earth, and consider every inch a mile, we should still have to make from twelve to thirteen such journeys, before we should pass over as many of these imaginary miles as would equal the number of real miles between us and

Uranus. Adopting the universally received time for the passage of light from the sun to us, 499 seconds, we get as the time required for the passage of light from Uranus to us, two hours and thirty-one minutes. So then, though we could pass through space at the rate of light, 186,300 miles a second, we should yet in going to Uranus be exposed to the terrible cold of outlying space for more than two and a half hours.

The great distance of the planet has so far made it impossible for astronomers to determine for certainty the rate of its axial rotation. There is little doubt that the planet does revolve on its axis; and it is quite generally held that the time required for its axial rotation is about the same as that for Saturn.

Uranus appears to be almost perfectly spherical; and it is thought that its edges are brighter than its centre. The mass of the planet is 14.7 times that of the earth, its volume 65 times; and its orbital velocity is 4.2 miles a second. The great distance of this planet is another illustration of the general truth that as bodies increase in distance from the sun, their orbital velocities decrease. The general law is thus expressed: the squares of the times of the planets are as the cubes of their distances. The earth, being about 92 million miles distant from the sun, moves in its orbit about 18.38 miles a second; but Uranus, being about 1780 million miles distant, moves about 4.2 miles only a second in its orbit; and the planet takes not less than 84.02 years to make one revolution around the sun.

The density of Uranus is about one-fourth that of the earth, and one-half greater than that of Saturn; in exact figures it is .225 considering the earth as unity, and 1.22 considering water as unity. At the planet's surface gravity is .91.

Uranus has several satellites. It is universally admitted that Herschel discovered two of them; for he observed them frequently between 1787 and 1810. Two others nearer to the primary body were discovered afterwards in 1846 by Mr. Lassell of England, with his reflector of two feet aperture. The periodic times of two of these satellites were computed by Herschel. For Titania he found its period to be 8.705897 days, and for Oberon 13.463269. Mr. Lasell determined in the clear skies of Malta the periodic times of the other two, Ariel and Umbriel, finding 2.520383 days for the period of the former and 4.144181 for the latter.

The strangest phenomenon in regard to these satellites is their great inclination to the plane of the ecliptic. So great is it that these planets move from east to west instead of from west to east, as the bodies of the solar system in general. In a geometrical sense their orbits are more than perpendicular to the plane of the ecliptic, since they make an angle of more than 100° with it. If we suppose that these bodies had in the beginning movements like other solar bodies, then in order to have a correct idea of their present motion, we must imagine that the planes of their orbits have been upset, as it were, until their north poles are about 8° below the ecliptic instead of 90° above it. When this happens the motion which first they had from west to east, will appear to be from east to west. No reason for this peculiarity has even been given. It is universally held, however, that there is nothing in these movements that can not be harmonized with the nebular hypothesis.

URANUS

Distance from the sun 1,780,000,000 miles; diameter 31,000 miles.

Periodic time 84.02 years; density .225, Earth being 1;

Volume 65, Earth being 1; mass 14.7, Earth being 1;

Time of axial rotation uncertain, probably about that of Saturn;

Gravity at its surface .91; orbital velocity 4.2 miles a second; synodic period 369 days 8 hours.

NEPTUNE

We have now come to the consideration of the outermost known solar satellite. For all practical purposes Bode's series expresses sufficiently accurately the relative distances of the planets from the sun; but the discovery of Neptune showed the series is not exactly true. Whereas the number in this series that stands for Neptune is 388, to express its distance correctly, it should be 300.6. The law does not hold good therefore in the case of Neptune.

The discovery of this planet is said to have created much more enthusiasm than even the discovery of Uranus. It was indeed a great triumph for the astronomer, and one of which he could not fail to be justly proud. The cause which led to the discovery of Neptune, was the irregular movements of Uranus. The planet appeared to show unmistakable signs of disturbances arising from the action of some unknown but neighboring body which, to satisfy the requirements, should revolve outside the orbit of the disturbed planet. From Besel's calculations of the discrepancy between the real and the calculated motion of Uranus, it was most surely believed that the explanation could only be found in the existence of another superior planet; and basing their calculations on Newton's laws, they launched their astronomical barque, determined to find the missing link, and bring it to port; and this they did. Adams, a young student of Cambridge, England, took up the work, and was not long in determining the orbit of a body which would, if it existed, be a sufficient cause for all the known disturbances. It was in October, 1845, when Adams handed Professor Airy the elements of a body answering all the requirements. This calculation would have enabled Professor Airy easily to find the planet, had he made a search for it; but Airy seemed not much interested in the search for the planet nor in the welfare of the young man; so he did not trouble himself

The wise not always wise!

about the question. In the mean time Leverrier, of France, was working on the same problem. His elements of the missing planet were made public the following summer, and were found to be about the same as those of Adams. The agreement in the calculations of the two mathematicians set the astronomical world at work; and the planet was discovered by Dr. Galle, at Berlin, September 23, 1846. This was justly considered one of the greatest triumphs of astronomy ever known. None can help sympathizing with poor Adams, who lost the glory which might have been his, had it not been for the incredulity of the artronomer royal. But although the technical right of discovery is given Leverrier, astronomers in general accord equal honor to Adams for his share in the work.

The distance of Neptune from the sun is 30.05437 astronomical units; this is a little more than half again as great as the distance of Uranus. Taking the time required for light to come from the sun to us as 499 seconds, and multiplying this time by the unit distance of Neptune, we find that it would require no less than 4 hours 9 minutes and 27 seconds for the passage of light from Neptune to us. If some dire catastrophe should therefore occur in the body of that planet, destroying its planetary character, it would be more than four hours before we should know anything about it; in other words it would appear to us to be still in its old place among the sun's attendants, reflecting the light of our central orb, for more than four hours after it had ceased to be.

Thirty-five miles an hour is a good average rate for the movement of an American passenger car. At this rate incredible as it may seem, to go to the planet Neptune, it would take not less than one thousand four hundred and twenty-six years. Considering each generation of mortals as embraced by the span of thirty years, should humanity set out at this rate of speed to go to Neptune, no less than 348 generations would have passed away, and the 349th be fast hastening to its end, before our descendants would reach the promised land; and perhaps then it would not be found to be "flowing with milk and honey." And yet this far-off body is Earth's brother, a descendant from the same common parent, moved by the same might, governed by the same laws, and dependent on the same central force for being and creative power. When we think of the sun, one is almost led to say, "who can escape thy wrath, or whither shall thy creatures go to hide themselves from thy all-searching gaze?" But on further contemplation we realize that there is a limit to the sway even of the sun, wide as may be his dominion, and mighty as that monarch is; for astronomy teaches us that the rulers in nature's vast expanse are jealous of their respective rights. And further study brings us the knowledge that the sun is not able to encroach on the dominions of those mighty kings whose thrones are emblazoned in silver and gold on the starry vault of heaven; nor is he likely ever to make the attempt.

To all appearance Neptune and his attendant occupy the extreme limits of the sun's rule; nor have we need to be ashamed of our ruler, small as he may be; for he is neither unstable nor capricious; nor is he ever known to deal out unequally his favors, nor show undue regard for any one of his subjects more than for another. Never having occasion to fear the loss of allegiance, never having any cause to use bribery in an election contest, or to purchase adherents with promises of preferment, he moves along his course steadily and quietly, conscious of power to govern and control, and fearless in carrying out the determinations of his own mighty breast. He is thus perhaps the only king in our cosmos who throughout his whole reign hesitates not to "tell the truth and shame the devil."

Neptune moves very slowly in its mighty orbit, moving each second only 3.36 miles; whereas Mercury, in the same time, goes no less than 29.55. Were we living on Neptune our period of life would enable us to make but a very small portion of its circuit; for this far-off planet takes no less than 164.78 years to make one revolution around the sun. Great as is its volume, so small is the density of the planet that gravity on its surface is only .89; and its density, considering Earth unity is only .204. With the exception of Saturn Neptune is the lightest of all the planets, volume for volume. Its distance from the sun is 2,791,600,000 miles; its mean diameter 34,800 miles; its volume 85, and its mass 17.1 considering the earth unity. The rate of its axial rotation has never been determined; although in all probability it is similar to that of Saturn.

Although Neptune seems the extreme limit of the sun's rule, it must not be imagined that this planet's domain marks the absolute boundary of the sun's sway. The truth is quite different. We know that the sun's sway extends through space at least thirty times farther than Neptune's orbit. At the awful distance from which light would require five or six days to come to us the sun rules quietly and peacefully, but no less surely and irresistibly. Great as we think the distance of the earth from the sun, the power of our central orb is everywhere felt throughout the vast profundity of space extending along radii, running out from its great heart, not less than 70,800 million miles. It might be asked, how do we know? We answer that the sun's power compelled the great comet of 1680 to return in its orbit, after it had receded no less distant than we have stated; and this is conclusive proof that all within this space is subject to the sun's behest. It is to be presumed that every portion of space, from the opposite limit of the empire of the nearest fixed star to the opposite limit of the empire of the sun, is divided between these two ruling bodies. The extent of their respective territories or dominions will be proportional to the square root of their masses, and the spheres of space ruled by them will be proportional to their respective masses. Now the nearest fixed star is Alpha Centauri. In speaking of the distance of this star it is common to use light-units; but we may in common language say it is set down as being about twenty-one millions of millions of miles away from our sun. This is somewhere about 228,000 times the earth's distance from the sun. To reach this star travelling on a railroad at the rate of forty miles an hour, would require not less than sixty million years. Even a cannon ball passing at the rate of one mile in five seconds, would take 2,550,000 years to go the journey; and even light itself takes about four years to come from Alpha Centauri to us.

Now if we knew the masses of the sun and star it would be possible to know their respective dominions throughout this vast space; but even though the sway of Alpha Centauri extended twice as far as that of our sun, still we should have more than seven millions of millions of miles for the radius of the space in and throughout which the sun is absolute lord and master. So then although Neptune's orbit appears the limit of the sun's power over planets, it still commands the obedience of numerous other bodies, moving in still wider circles, almost inconceivably farther removed than is Neptune. Without doubt there may be messengers of more lordly potentates, which sometimes pass through the territory of the sun with such tremendous power that he is totally unable to overcome them. He sees them come and go; but think what he may, he is powerless to prevent these incursions. Still it may be laid down as a rule that the sun is a dangerous monarch to trifle with; and that the only way for a body that does not wish to submit to his government, is to keep out of his dominions. In certain instances strange visitors have trespassed on his patience too much; and in his wrath he has bound them fast to his chariot, and held them captive, or hurled them headlong into his furnace of fire to raise the temperature of his outlying dominions.

The color of Neptune is greenish blue; by some it is said to be pale blue. The planet can not be seen by the naked eye. Even with a large telescope, and in the clearest atmosphere it presents a disk of only about 3″ in diameter. On the surface of the planet little markings, if any, have ever been noticed; therefore nothing definite is known concerning its axial rotation.

Neptune is accompanied by at least one satellite. This was discovered by the English astronomer Lassell in 1846. Its period is 5 days 21 hours 3 seconds. The satellite even in the most powerful telescope is a very minute object. Its diameter is about that of our moon, and its distance from the primary 224,000 miles. Its orbit is retrograde like those of the satellites of Uranus, and from similar cause. Its orbit has seemingly been completely tipped over, or upset, not less than 150°; in fact the orbit is almost up-side-down.

NEPTUNE

Periodic time 164.78 years; orbital velocity 3.4 miles a second;

Distance 2,791,600,000 miles; diameter 34,800 miles;
Volume 85, Earth being 1; density .20, Earth being 1;
Mass 17.1, Earth being 1; gravity at surface .88;
Axial rotation uncertain; synodic period 368 days.

CHAPTER VI

COMETS AND METEORS

COMETS

PERHAPS the most wonderful bodies in the heavens are comets. In aspect they are frequently most awful, and in shape most fantastic. They have been, at least until these late days, the dread of man, filling him with consternation, expectation of the end of the world, and fear of Divine wrath.

Although comets are not of every day occurrence, they are nevertheless very plentiful in space; indeed Kepler said of them that they are as thick as fishes in the sea. Sometimes these bodies have a nucleus, sometimes not; some appear with tails, others with none; some with a single tail, others with many.

The scholars of China, in very early times, made quite accurate records of the appearance of comets; and the earliest calculations of modern astronomers of cometary orbits, were based on Chinese observations. Especially is this true of the comets of the years 539, 565, 574, 837, 1337, and 1385. With reference to the appearance of comets, their path in the heavens, the times of appearing and disappearing, the Chinese records reach back several centuries before the Christian era. While Europe paid little or no attention to such things, the Chinese on the contrary studied them minutely, marking the times of their appearance, the parts of the heavens where they were first seen, and the names of the constellations through which they passed.

The nucleus of a comet presents as a rule no definite outline, no well defined disk; to this however there are exceptions. It is said that the great comets of 1402, 1532, 1557, 1742 and 1843 could be seen in bright sunshine; and from this it has been concluded that the nucleus, under certain conditions, may shine more brightly than by reflected light only. Only two comets were said by Herschel to present well defined disks, that discovered in Sicily in 1807, and that of 1811. The diameters of these as given by Herschel were 535 and 428 miles respectively.

The gaseous nature of comets was known to the ancients. Aristotle says that Democritus had stated how he himself had seen stars through comets; and Seneca tells us that one can see the stars of heaven through the tails of comets; "but" he says, "through the body itself of the comet thou canst not see."

Comets in general have small masses, perhaps the smallest, volume for volume, of any heavenly body; but their dimensions are as much larger as their masses are smaller. The tail or cone of luminous vapor which is thrown out by some of them, is of vast dimensions, in some cases longer than the earth's distance from the sun, forming a line that intersects the orbits of Venus and Mercury. It is believed that the vapors of the comets of 1819 and 1823 mingled with our atmosphere.

Concerning the motions of comets the Pythagoreans, among the ancients, taught what to-day is generally known to be true, that they are planetary in character. As to the number of comets we have but little knowledge; but without doubt they are very numerous. Not less than five hundred have been noticed since the beginning of our era; the average being one every four years. The greatest number were seen in the third century, the next greatest in the ninth, the next greatest in the eleventh and eighteenth centuries, and the next greatest in the sixteenth century. More are discovered in these late days because of having more powerful instruments.

The comet of 1680 was very brilliant; and it was from the study of this, which was visible from the autumn of 1680 to the spring of 1681, that Newton proved that comets are solar attendants, moving under the influence of the sun's gravity, and therefore in orbits more or less regular around the centre of our system. It is said that this comet fell down almost in a straight line to the sun, passing nearer to that burning luminary than any other body was ever known to pass, pretty near to the point of certain destruction. The exact period of this comet has not been determined; but Halley believed it was 575 years, and connected it with some reported appearances of great comets such as that which was seen in the September following the murder of Julius Cæsar, and that of 531, that of 1106, and that of 1680. The comet of August 19th, 1682, was perhaps the most celebrated of modern times; especially from the fact that Halley computed its orbit, and found it makes a revolution once in about 75 years. It is supposed that this was the comet that had been seen in 1456 which filled the whole of Europe with terror, and caused Pope Calixtus to order prayers to be offered for protection against Turks and comets. Halley calculated that it would return in 1758; but owing to the attraction of Jupiter's satellites its coming was delayed some months, the comet appearing March 12th, 1759. Again it was predicted that it would appear in 1835; and on August 5th of that year it was sure enough seen, remaining visible till May 17th, 1836, when it disappeared from sight of the most powerful telescopes of that day. It is believed that this comet arrived at the farthest limit of its course about the year 1873, when it was far beyond the orbit of Neptune; and that it is now on its way back to us, and likely to be at perihelion in April or May of this year, 1910. In the year 1826 an Austrian named Biele discovered a comet. iod was found to be six years and eight months; as thought to be the same body as had been seen in 1772 and 1805. When it made its next two appearances the earth happened to be in such a part of its orbit, that the comet was not visible; and we had to wait until 1845 to see it again. When seen in November and December of this year, it had its former appearance; but the following January the world was surprised to find that the comet had separated and become two. In February the smaller portion grew larger and larger until it equalled the larger part; then beginning to get smaller and smaller, in March it disappeared altogether, the other part remaining visible for another month. It is supposed that at the time of the disappearance of the smaller part, the two parts of the comet were 200,000 miles apart. In 1852 the comet returned again, and the two parts were seen as before, but now not less than 1,500,000 miles asunder. Each part was about equal in size and brightness. In September, 1852, both parts disappeared, and from that time have never been seen. It is now generally believed that this comet has been broken up into meteoric showers, especially since a shower appeared about the time the comet was due.

In 1811 appeared a comet that is believed to have a period of about 3000 years. It was visible in full daylight, and is supposed to have come within 50,000 miles of the sun. To escape destruction it rushed by at the rate of a million miles an hour or more. The comet of 1874 is called Coggia's. It was very brilliant, and was examined with the spectroscope, and found to have been made up largely of hydrocarbons. Coggia's comet moves in an ellipse having a very long major axis. Thousands of years are necessary for it to make one revolution. In 1882 a remarkable comet passed between the earth and sun. On leaving the sun, the head of the comet broke into several parts. In 1901 a bright comet appeared in the southern heavens. Its tail was double and not less than 7° long.

The planes of the orbits of comets lie in all directions;

their paths therefore are anywhere and everywhere. Such being the facts, it is not reasonable to hold that a comet can not collide with the earth. The heads of some comets are very large, that of 1811 being probably not less than a million miles in diameter. The comet of 1882 had a tail not less than 100,000,000 miles in length. This comet was seen in many parts of the world. Sunday, September 17th, it was seen very near the sun. In the afternoon it seemed about to make a passage across the sun's face, and astronomers were full of high expectations; but the sun disappeared at the Cape of Good Hope before the event occurred; and Dr. Gill, the English astronomer at that place, failed to get the information he sought in going there. The comet, however, was seen by Mr. Finlay and Dr. Elkins, at the Cape, to enter on the sun's limb; but the sun disappeared behind Table Mountain too soon for satisfactory observation. These observers assert that the brilliancy of the comet's nucleus was hardly less than that of the sun itself. It was first believed that this comet and those of 1843 and 1880 were one and the same; but further calculations showed that the speed with which it was falling to the sun, made this supposition untenable.

Encke's comet has caused much speculation on the question of a resisting medium. This body was first seen in January, 1776. Its motion was thoroughly investigated by Encke of Berlin, and its period found to be 1200 days. He predicted its reappearance in 1882; and Sir Thomas Brisbane, searching the heavens in New South Wales, found it according to expectation. Encke continued his investigations of the movements of this comet till near the time of his death, and found its period was all the time diminishing to the extent of about two and half hours each revolution. This fact made Encke, Olbers, and others believe in what is called a resisting medium—a rare substance supposed to fill all space, and to be such that although too rare to affect the movements of the planets, it can affect the movements of cometary bodies. The existence of such a medium is questioned by many astronomers. Granting its existence, it seems unreasonable to hold that a substance sufficiently dense to affect the movement of a comet, can have no effect on the movements of the planets; for however subtile such a substance be, still its resistance can not be equal to zero, and must therefore have some effect, however little, on the motions of the planets.

The orbit of a comet may be either an ellipse, a parabola, or an hyperbola. Those having elliptic orbits belong to our system; those having either parabolic or hyperbolic may visit us, but disappear, probably never again to return. It is not impossible for a comet moving in one of these curves to have its orbit changed into another, through the attraction of planets or other bodies across whose paths the comet may have fallen.

In general comets can not be seen if their perihelion is not inside, or but little outside, the orbit of the earth; although there are some exceptions, for the comet of 1729 was so brilliant and large that it was plainly seen although its perihelion distance was at least four times the earth's distance from the sun.

It is readily seen that those comets which belong to our system, and come into view having such terrific speed, must move at a relatively slow rate when at the farthest points in their orbits from the sun. Indeed, it is said that their speed at that time can not greatly exceed ten feet a second; and this is not so fast as water moves in some rivers. Argelander said the period of the comet of 1811 is not less than 3065 years; and the very large comet of 1680 is said to have a period of not less than 8000 years. Even at such vast distances beyond the orbit of Neptune does the sun hold these strange bodies tightly in his grasp. Alpha Centauri, our nearest neighboring sun, is at least 250 times farther than the extreme limit of the orbit of the more distant of these comets.

Mr. Faye of France doubts the truth of the view of LaPlace concerning the hyperbolic character of cometary orbits; and says that on the contrary out of 146 whose orbits have been determined, not one shows a decided hyperbolic orbit. This eminent authority maintains that the natural orbits of comets are elliptic.

A comet frequently shows three parts—the nucleus, a coma, and a tail. The nucleus is the more condensed matter forming the head; the coma, a shining nebulosity round or oval in shape, and helping to form the head; a tail, the part always most distant from the sun, sometimes stretching out millions of miles. Bredichin divides the tails of comets into three kinds, the straight, the bushy, and the curved. He thinks the first is caused through repulsion by the sun of the cometary hydrogen; the next through repulsion by the sun of the hydrocarbons in the comet; and the bushy, through repulsion of less degrees. Much information has been obtained of late years through the examination of comets with the spectroscope. Hydrogen and carbon are the two gases commonly found constituting the bulk of comets.

Collision of the earth with a comet's nucleus is highly improbable; but so is the falling face upward of three sixes on six successive throws of three dice. Improbable as is our collision with a comet, the possibility remains with us forever. Such a collision might be of little consequence, or it might be immediate destruction, or a prolonged bombardment such as would leave us little hope of escaping the impending doom. It is said by some that an iron ball a hundred miles in diameter is probably equal in mass to that of the nucleus of any comet. But one does not like to contemplate the result of the earth meeting an iron ball a hundred miles in diameter moving with the velocity of from sixty to three hundred miles a second. Nor would our condition be much better if the tail of some of the comets were to completely enwrap us; for there would be little hope for the escape of any higher life, when forced to inhale such poisonous gases as seem largely to compose the more attenuated parts of many comets.

At the last appearance of Halley's comet, in 1836, the diameter of its head was no less than 350,000 miles.

As we have stated, the tail of a comet is always turned from the sun; and at the turning point in the orbit of a comet, it is known to be hurled back into space at the rate of eight or ten million miles a day. Through such enormous velocity it is thought that at times much of the nebulous matter forming the tail must be dissipated into space, and lost to the main body forever. The bending of the tail is thus explained: When first driven off by the sun the tail has the same rate of motion as the rest of the comet; but inasmuch as it is driven some millions of miles farther away from the sun than the nucleus is, it follows that having to describe a much longer arc, it must fall behind the rest of the body, and thus form a big bend or curve. In speaking of this Babbit says: "Comets move with their nucleus towards the sun, and their tails in the opposite direction. The cause of this is that the nucleus being more dense becomes first heated, then as thermo-electricity always moves from a warmer to a colder region, it must pass from the nucleus towards the colder realms of space, which necessarily must polarize the mass of the comet in a direction opposite to that of the sun." And the eminent physicist, Tyndall, speaking of the same phenomenon, says: "The tail is always turned away from the sun for this reason: two antagonistic powers are brought to bear upon the cometary vapor; the one an actinic power tending to produce precipitation; the other a calorific power tending to effect vaporization. Where the former prevails we have the cometary cloud; where the latter prevails we have the transparent cometary vapor. As a matter of fact the sun emits the two agents here envoked. There is nothing whatever hypothetical in the assumption of their existence. That precipitation should occur behind the head of a comet, or in the space occupied by the head's shadow, it is only necessary to assume that the sun's calorific rays are absorbed more copiously by the head and nucleus than the actinic rays. This augments the relative superiority of the actinic rays behind the head and nucleus, and enables them to bring down the cloud which constitutes the comet's tail. The old tail as it ceases to be screened by the nucleus, is dissipated by the solar heat; but its dissipation is not instantaneous. The shrinking of the head in the vicinity of the sun is caused by the beating against it of the calorific rays, which dissipate its attenuated fringe, and cause its apparent contraction."

In the case of a large comet the nucleus is sometimes as much as five thousand miles in diameter, and the coma not less than 200,000; while the tail has been known to reach the enormous length of 200,000,000 miles. It is said that the comet of 1861 extended over the heavens for 106°. Strange things are comets; and sometimes they come to us strangers from unknown depths of space; yet they are parts of the one universal body, and if we knew them truly, we should know that there is nothing in them really foreign to the rest of the body of the universe.

It is believed that there are not less than eight hundred comets known to-day; and that on the average about seven are seen annually.

METEORS

By the word meteors is meant every body classed in general under the three heads—shooting-stars, aerolites, and bolides. There is no scientific reason why these should be separately treated.

At the first sight of a brilliant meteor one is led to ask himself, if such a phenomenon is of frequent occurrence; and many investigators have labored for years for the purpose of being able to give a satisfactory answer to this question. In order to arrive at a solution the custom is to carefully count the meteors which display themselves in some definite part of the heavens in full view of the eye of the observer. The number thus seen by one observer, in some one place, will be to the number that might be seen, were there sufficient observers stationed all over the earth, as the portion of the heavens in view of the one observer would be to the whole sphere of the heavens. Among such observers but few perhaps labored so untiringly as Dr. Schmiedt of Athens. For seventeen years he observed this phenomenon with the view of answering our question. His conclusions were that the average number of meteors visible on clear moonless nights to one observer is fourteen per hour, the time of observation being from twelve, midnight, to one o'clock in the morning. Professor Newton says that the number which might be seen, were there sufficient observers stationed all over the earth, is no less than ten thousand times as many as can be seen by one observer; and Norman Lockyer calculates that not less than twenty millions of luminous meteors fall to our planet every day. But enormous as this number is, it is but a fraction of the total number that fall to the earth during this time; for it is certain that the telescope reveals a vastly greater number than are visible to the naked eye. Norman Lockyer says that were we to include in our calculation the number that through the telescope might be seen falling, we should find that no less than a grand total of four hundred million meteors fall every day to our earth. Considering those only visible to the naked eye, Professor Newton tells us, reckoning the velocity of meteors, as equalling that of comets moving in parabolic orbits, that the number of meteors in the space through which our earth passes, will average 30,000 for every earth-volume of space; and even this calculation, enormous as the number is, will allow, says Lockyer, two hundred and fifty miles of intervening space between every meteor and its neighbor.

Now it must be evident that were we to receive constant falls from impalpable powder even, dust would soon accumulate on our clothing; and ere long so great would be this increase that it would be a nuisance, or a load too much to bear. Thus we may see what must happen to the earth through this incessant fall of meteoric dust: the earth must grow in size, and of the truth of this statement, there is no room for doubt. Professor Nordenskjöld has made the calculation that the yearly increase in mass of the earth from the fall of meteors, is not less than a half a million tons. But if such a constant stream of meteors is ever pelting our earth, how much greater must that incessant torrent be which must be ever streaming into the bosom of the sun! We may reasonably believe that the sun's heat is in some measure replenished by this constant fall of meteoric bodies.

It is sometimes asked why more meteors can be seen a little after midnight, or in the very early morning, than at other hours. In reference to this Humboldt says: "It is difficult to conjecture the cause of such an hourly variation. If under different meridians the shooting-stars do not become especially visible until a certain early hour, then, in the case of their cosmic origin, we must assume what is still but little probable, viz., that these night or rather early morning hours are especially adapted to the ignition of the shooting-stars, while in other hours of the night more shooting-stars pass by before midnight invisible. We must still long and patiently collect observations." It seems to us however that the following may be accepted as a reasonable explanation. It must be admitted that in general the darkest hour is about midnight; and that the darker it is the more readily must shooting-stars make themselves visible. Again, the lowest degree of temperature is not reached until midnight or a little after; for up to this hour the heat absorbed by the earth from the sun, on the preceding day, has not had its maximum radiation; and since the condensation of atmospheric vapors, and the purification of the atmosphere in general, must to some degree depend upon the coldness of the air, it follows that the atmosphere will not attain its maximum of purity until midnight or a little after. With the fall of temperature condensation of vapors begins; and with the condensed vapors the various atmospheric impurities—floating particles, smoke, fogs, etc., will fall to the ground. This of course must result in a clearing of the atmosphere, and consequently in revealing more shooting-stars. Another reason is the fact that the observer's hemisphere of the earth is going to meet the falling meteors at that hour; and therefore more must be seen, as when a person goes against the falling rain, more drops will fall upon his breast.

A train of bright light generally accompanies the passage of a meteor through the earth's atmosphere. Most meteors are thus entirely consumed; and their substance is sometimes found in localities where its identity is not likely to be lost through mixture with terrestrial substances. Such places are the bottom of the sea, the tops of glaciers, high roofs, snowy wastes, etc.

If we think of the great speed with which meteors strike our atmosphere, and the resulting heat that must be produced by their impact with it, we shall have no difficulty in understanding why ignition so generally results from their passage through our atmosphere. Sir William Thompson has found by experiment the rate at which a thermometer will rise when placed before a rapidly moving body. A rate of 125 feet a second, he finds, will cause a rise in the thermometer of one degree. Regarding this 125 feet as the unit, he finds that for different velocities the rise in temperature will be equal to the square of the quotient found by dividing the velocity per second by 125.

Now the average velocity of meteors, when they come into our atmosphere, is set down as about thirty miles a second; and as very many move in an opposite direction to that in which the earth moves, it follows that the speed at which such meteors strike our atmosphere, is increased by that of the earth, which is 18.38 miles a second. This will make the velocity of some meteors at least fifty miles a second. Norman Lockyer says that if a meteor going a mile a second be immediately arrested in its motion, the increase in temperature will be 3000°C.; going thirty miles a second, 2,700,000°C.; and going sixty miles a second, 10,800,000°C. We have no knowledge of any substance that could stand such temperature.

We do not suppose that the portion of space through which the earth moves, is any more crowded with meteors than is space in general. Admitting this, it must follow that since meteors move in every conceivable direction, dashing hither and thither, passing and repassing, crossing one another's path, and flying in directly opposite courses, there must be constant collision among them. From such collisions there would sometimes result broken fragments, sometimes an enlarged mass, sometimes a united mass of vapor. In the former case, out of one would happen many; in the last two cases, out of many would happen one. Such conditions and results would seem to be sufficient to explain the formation of comets.

Meteors bring us strong testimony concerning the unity of the universe, and the similarity of its substance. They come at times visitors from great depths, yet they come stamped with nature; and none can doubt that they have been raised in the same mother's arms that nursed the earth and the other planets of the solar system. In our own families we find the different members having certain peculiarities in dress, carriage, and temperament, although they are evidently one. Thus with meteors: we find that they have a structure quite characteristic, and in many ways different from that of earthly substances; yet in no case has any unknown element ever come to us in these foreign bodies. Different in many ways as these bodies are, yet they are one with the earth; and of this unity they leave no room for doubt.

Sir William Thompson says that if we allow 44 miles a second as the average velocity with which a meteor strikes our atmosphere, the temperature of the air surrounding the meteor will be 3,454,245.2736 degrees. Surely at such a temperature there could be little failure of the ignition of any body known to us. Says Newcomb: "A few grains of platinum striking the atmosphere with the velocity of the celestial motions, might evolve as much light and heat as are emitted by the burning of a pint of coal-oil or several pounds of gunpowder; and the whole operation is over in a moment. We may imagine how intense the heat and light must be."

There are two well-defined classes of meteors, the one sporadic, the other belonging to a stream or shower. These showers were noticed by the ancients from time almost immemorial; and they have produced great consternation in the minds of both ancients and moderns. Says Diogenes of Apollonia: "Invisible masses of stone move with the visible stars, and remain on that account unknown. The former sometimes fall upon the earth, and are extinguished, as happened with the stony star which fell near Aegos Potomos." At the time of the great victory of Lysander over the Athenians, Anaxagoras of Clazomena was thirty-two years old. According to this writer the meteors are masses torn away from the earth through the rapidity of the earth's motion. He thinks the whole heavens may be composed of stones. These stony bodies, he says, are made to glow by friction with the ether, and they therefore reflect the light that is thus communicated to them. The Cretan Diogenes says that "falling stars are not ejections and waste of the ether's fire; they are much rather the offshoot of celestial bodies of such nature that by slackening of their revolution they are shot down." Plutarch tells us that if the moon were to slacken its speed, it would fall to the earth as if shot from a sling. An Arabic work says: "In the year 599, on the last day of Moharrem, stars shot hither and thither, and flew against each other like a swarm of locusts. This phenomenon lasted until break of day. People were thrown into consternation, and made supplication to the Most High. There was never the like seen except on the coming of the messenger of God, on whom be benediction and peace." The Portuguese historian, Duarte Nunez, of Liao, speaking of a fall of meteors that occurred October 22nd, 1366, says: "In the year 1366, and twenty-two days of the month of October being past, three months before the death of the king Don Pedro, there was in the heavens a movement of stars such as men never saw before. At midnight, and for some time after, all the stars moved from the east to the west; and after being collected together, they began to move some in one direction, and others in another. And afterwards they fell from the sky in such numbers, and so thickly together, that as they descended together they seemed large and fiery, and the sky and the air seemed to be in flames, and even the earth appeared as if ready to take fire. The portion of the sky where there are no stars seemed to be divided into many parts, and this lasted for a long time. Those who saw it were filled with such fear and dismay that they were astounded, imagining they were struck dead, and that the end of the world had come." Petrus Martyr, of Anghiera, in describing a fall of meteors that occurred September 4th, 1511, says: "The report is that an enormous peacock was seen flying in the sky above the town of Crema. The peacock appeared to change into a pyramid, and was carried from west to east with such rapidity that in a moment it seemed to travel the whole hemisphere, as some learned men imagined who saw it.

Immediately afterwards such darkness arose from the denseness of the clouds as was never known by mortal before. During the midnight gloom unheard of thunders, mingled with awful lightning, resounded through that quarter of the heavens. On the plain of Crema, where never before was seen a stone the size of an egg, there fell pieces of rock of enormous dimensions and of immense weight. It is said that ten of these were found weighing a hundred pounds each. Birds, sheep, and even fish were killed."

The most important meteoric showers are those of August and November; and it is through an historical investigation of the character of this latter shower, that astronomers have been led to regard meteoric showers as sometimes the passing of comets. The history of the November shower has been traced back more than a thousand years; and what Olbers suspected, is found to be true: this shower occurs about every thirty-three years, and happens about two days earlier every century as it is traced backwards. These facts have led astronomers to conclude that the November shower revolves in a definite orbit around the sun, which intersects the orbit of the earth, the point of intersection moving forward about 52° a year, owing to a change in the position of the meteoric orbit. This swarm of meteors is not equally scattered at all points of its orbit; but the thickest portion extends along about one-fifteenth of the whole. Once in about thirty-three years does the earth meet this swarm, and it succeeds in making another revolution before the swarm has entirely passed. This swarm is therefore seen on two or three successive years about every thirty-three years. Schiaparelli, an Italian astronomer, and Leverrier of France, were led to believe that there was an intimate relation between this swarm and Tempel's comet. The results of the investigation of these astronomers were handed the French Academy of Science, January 27th, 1867; and it was soon concluded that the November shower followed or was a part of Tempel's comet; for the period of the shower and that of the comet coincided. This being determined Schiaparelli began to investigate the character of the August shower of meteors; and he was not long in finding an intimate relation between it and the comet that appeared in 1862; and it is now accepted that this shower of meteors is part and parcel of this comet. On November 27th, 1885, some meteors were found in Mexico; and on chemical analysis they were held to be from Biele's comet.

The great and only difference between the August and November showers of meteors is, that whereas the November shower is seen at the intervals given above, the August shower is seen every year. It is supposed that the November shower has lately come into our system, perhaps in the early part of the Christian era; whereas the August shower is believed to have been a member of our system at least twenty times as long. Leverrier thinks that Uranus was the cause that brought the November shower into our little cosmos; and he fixes the date of this occurrence at 126 A. D.

The general opinion concerning meteors and comets today is that the latter are no more nor less than a conglomeration of the former. This may seem hard for some to believe; but it may help such to a clearer understanding of the matter by recalling to mind the fact that the clouds and fogs and smoke which float over our heads, are but a conglomeration of very small particles of matter of some kind.

In addition to these two world-famous streams there are many other lesser meteoric swarms. Denning, a prominent English authority, classifying them generally after their radiant point, names them thus: Quadrantids in January, Lyrids in April, Eta Aquarids in May, Delta Aquarids in July, Perseids in August, Orionids in October, Leonids in early November, Andromedes in late November, Geminids in December.

We sometimes see very brilliant meteors, and afterwards quite large masses fall to the earth. The light as we have said is caused through the more or less complete ignition of the body; and the loud sound we hear, sometimes by the bursting of the meteor, or more frequently by the rushing of the air into the wake of the meteor, or perhaps by the sudden compression of the air in front of it. The light from meteors is supposed to be first seen when they are at an altitude of about 75 miles. In general the light disappears at an altitude of about 55 miles, the body being then entirely consumed. Sometimes the body is so large that it is not entirely consumed through its rapid flight in the atmosphere. As a result, it is thought, of atmospheric pressure we have sometimes an explosion followed by the fall, in certain instances, of small fragments of the aerolite to the earth. At other times a bright light is seen accompanied by a most fearful noise, and the fall of large bodies to the earth without explosion.

A great many of these fallen bodies have been examined, but in none has there ever been an element found not already known to us. Meteoric masses have been known to fall in almost every part of the world. In Siberia one found by Heiss proved to be 1270 Russian pounds. Similar masses have been found in Mexico, Greenland, South America, Europe, and Hindostan. Some celebrated meteoric iron masses were found in Siberia, Ovifak, on the island of Disco, off Greenland, in Brazil, and Tennessee. In these masses the least per cent of iron is 63.69, and the highest 91.15.

The substances found in meteors are oxygen, sulphur, phosphorus, carbon, nickel, cobalt, chronium, manganesium, copper, tin, and titanium; and "Nature" of December 1st, 1887, gives an account of a meteor which fell in the district of Krasnoslobodsk, government of Pensa, Russia, which was said to contain one per cent of pure diamond; and in the same scientific journal, of the same date, there is an account of another meteoric stone which fell in

Perm, August, 1887. It is said to have been 1100 lbs., and to contain particles of unoxidized nickel-iron.

From whatever depths of the universe comets and meteors come, it is seen they bring with them the highest proof of common motherhood with us. In the year 1867 Prof. Graham, while delivering a lecture before the Royal Institution of London, had his lecture-room all lighted by the means of gas which he had obtained from a fallen meteor. Thus do these bodies bring with them indisputable proof of a common origin.

It may be said that the structure of metoric masses is so peculiar that mineralogists accustomed to examining them, can readily distinguish an aerolite from a similar mass of earthly origin. A half volatilized, indented, and thumb-mark appearance is quite characteristic of these celestial bodies.

CHAPTER VII

THE EARTH

OF all planets belonging to the solar system, Earth is best known to us, and the one with which we are most closely connected. Such language must be understood, however, only in general terms; because the solar system is, as it were, one single organism, every part of which is most closely connected with every other part. As in the animal a diseased limb induces a sympathetic state in other parts of the body, and frequently pain much greater than that felt in the true seat of the disease; so in the solar system, a disturbance in one member is felt throughout the whole, and the failure of one to perform its allotted work, might lead to yet more dire catastrophe in another. Still we have in a narrow sense the right to say that with Earth we are more closely connected than with any other planet.

It is a wonderful globe, and one that in more than a figurative sense is very near to man. "As by nature," says Aristotle in his Economics, "all receive nourishment from the mother, so are we thus related to the earth."

The shape of the earth is that which a body of water equal in weight and revolving on its axis in equal time, would assume; and this has led many physicists to conclude that our globe was once beyond reasonable doubt in a fluid state.

The earth not being a perfect sphere, the centre of gravity is not exactly in its centre. If a body could be dropped from the equator or from either of the poles, it would pass directly through the centre of the earth; but if dropped from any other part, although as it left the surface its tendency would be nearer and nearer to the centre, it would not pass through it. This ellipsoidal shape of the earth is also partly the cause why a body has not the same weight on all parts of the earth's surface; for a body weighs differently as it is nearer or farther from the centre of gravity. Another reason for the difference in gravity, on different parts of the earth's surface, is its equatorial motion; this motion imparting to every body a tendency to fly off from the earth's surface, proportionate to its nearness to the equator. Because of this tangential force a body weighs less at the equator by 1/289 of its weight. We have therefore two causes which at the equator decrease the weight of bodies, the ellipsoidal form of the earth and its axial rotation. Newton, Maclaurin, and others have shown that owing to the ellipsoidal form alone of the earth, a body must increase in weight, passing from the equator to the poles, by the 1/590 of its own gravity. This difference added to that caused by the tangential force, gives us for the total gain in the weight of a body passing from the equator to the poles, the 1/194 of its own weight. If the earth were to revolve on its axis in 5069 seconds, matter at the equator would lose all its gravity, and therefore would move freely in that part of the world. Such a rate of motion would be about seventeen times the present rate of the earth's axial rotation.

The circumference of the earth is about 24,000 miles and its diameter about 7912. It is an easy problem for any person to determine very nearly correctly the diameter of our earth. Suppose you knew the exact height of a mountain to be two miles, and that it is visible 126 miles at sea or on a level country. Then the height of the mountain is to the distance it is visible, as this distance is to the earth's diameter. This would give for the diameter 7936 miles, which is about correct. This method would be strictly reliable, were it not for the uncertain character of refraction near the horizon. Still a simpler method for determining the earth's diameter is the following. Let the height of a mountain be known, and the distance it can be seen; then we can determine the earth's diameter sufficiently accurately for all common purposes by a very simple geometrical formula. If we let the height of the mountain be *d*, the distance it can be seen be *g*, and the diameter of the earth be *x;* then *x* square plus *b* square will equal the square of (*x* plus *d*). So too a rough estimate of the earth's circumference can be obtained by finding the correct latitude of two places on the same meridian, and then measuring the distance between these two stations. The distance thus obtained will be to the circumference of the earth, as the number of degrees found to be in the arc is to 360, the number contained in every circle. In this way a person can have quite clear ideas about the size of our globe. In obtaining exact measurement by these methods we meet with many difficulties, which tax one's patience, and make these methods too cumbersome for general adoption by the scientist seeking exact measurements. Nevertheless they are sufficient for the purpose of opening our eyes to correct knowledge about the globe we live on.

I have spoken of refraction as one difficulty in measuring the circumference of the earth, by the distance a known mountain may be seen at sea. Every one knows that if he places a stick in the water, it seems to bend toward the perpendicular, or appears bent or broken. It is thus with the rays of light in passing from a rarer into a denser medium. When we look at a heavenly body in our horizon, it is evident that it is seen through a greater depth of atmosphere than if seen in our zenith. Refraction is therefore greatest at the horizon, and zero at the zenith. To illustrate the degree of refraction, suppose you were to see at any moment a star to pass your zenith at the equator, then it is evident to all that four hours afterwards its zenith distance should be four times fifteen degrees, the number of degrees the earth revolves in one hour, and its altitude should be exactly thirty degrees. But should you observe the star at this time, you would find its altitude to be 30° 1′ 40″. This 1′ 40″ is the amount of refraction corresponding to 30°. In six hours after such star had passed your zenith, it should be in your horizon; but you would find it 34′ 30″ above it; and this, therefore, is the amount of refraction at the horizon. By taking observations in this manner, the correct refraction for every degree may be found from the zenith to the horizon. One effect of refraction is to make the sun appear in our horizon, when it has already set, and before it has arisen. Thus the length of the day is increased, and more than half of the earth's surface is constantly illuminated, the extra illumination equalling a zone forty miles wide all around the earth. At the equator the length of a day is increased by refraction more than four minutes; and the nights lessened four minutes. At all other places the difference is more than at the equator, owing to the obliquity to the horizon of the diurnal circles. In very high latitudes near the poles, the sun, through refraction, appears above the horizon four days longer than it otherwise would. Again, full moon occurs when the moon is exactly opposite the sun; and were there no atmosphere, the rise of the full moon would be simultaneous with the setting of the sun; but because of refraction we see the rise of the full moon before the sun has set. When the sun or moon is in the horizon they appear in oval form; this also is owing to refraction. The lower limb being in a denser medium, it is subject to more refraction than the upper. In all astronomical observations, refraction must be allowed for with great care.

The earth revolves around the sun once a year. If you should watch any well known star, or group of stars such as the Seven Stars, the Belt of Orion, Aldebaran, Sirius, and the like, and note the exact time when such comes to any chosen position, as over a wall, or any similar place, you will find that the star will pass this place every evening just four minutes earlier than it passed the preceding evening. This fact is explained when we know that in that time the earth has moved through space around the sun just about one degree; and therefore one degree less than a full revolution on its axis will bring the object, the observer viewed the day before, to the same position in the heavens.

The earth is a very dense body. It is sometimes supposed that the interior of the earth being at a very high temperature, must therefore be less dense as the centre is approached; but this is not so. By experiments conducted by Cavendish, Bailey and others, it has been well enough substantiated that the mean density of the earth is about 5.67 times that of water. That is our globe is 5.67 times heavier than a ball of water having equal volume. It is thought that the state of matter in the interior of the globe must approach that of a fluid having an infinite viscosity. It is not believed that the so-called solid crust of the earth can extend to a much greater depth than 25 or 30 miles; for the increase of temperature is found to be, on the average, one degree for every 50 ft. of descent. This would give us a temperature, at a depth of 30 miles, above 3000 degrees, a temperature sufficient to melt any rock substance known to us. Yet the enormous pressure to which the interior matter must be subjected, probably increases the melting point. Says Daniel, quoting from Osmond Fisher: "If the earth have a crust 25 or 30 miles thick floating on a melted magma, at increasing depths the pressure, which near the centre must amount to about 45,000,000 lbs. per square inch, would compress the liquid so much that, though melted, it would have a viscosity so extreme that the mass would have the same relation to extraneous forces as a very rigid solid body would have. The earth would, in consequence of this, comport itself as if it had a solid nucleus floating in, and merging by gradations of relative softness into, a thin liquid layer on which the crust floats." (Daniel's Physics, 213.) Mr. Dana says that at a depth of 28 miles below the surface the fusion point of iron must be reached.

It is known to all that the earth has a daily revolution on its axis, and a yearly one around the sun. The plane of its orbit around the sun is not parallel or one with the plane of its equation; but it is inclined to the latter at an angle of 23° 56′ 4.09″. It is this inclination of the plane of the earth's orbit to the plane of its equator that is the cause of our seasons; for without this there could be no change of seasons except what might result from the difference in the sun's distance from the earth at different times of the year. It is evident that the plane of the earth's orbit cuts that of the celestial equator (which is simply the terrestrial equator indefinitely extended) at two places only, which are called the equinoxes; and the two parts of its orbit most distant from the plane of the equator, are called the solstices, the former term signifying equal days and equal nights, and the latter, turning points. The vernal equinox occurs about the 21st of March, and the autumnal about the 23rd of September; the summer solstices occurs about the 22nd of June, and the winter solstice, about the 22nd of December. In its revolution about the sun, the earth moves in an elliptic orbit, and at the rate of 18.393 miles a second; and in its revolution on its axis, it revolves at the rate of 17 miles a minute. In its orbit around the sun, it moves about 65 times as fast as in its revolution on its axis.

It is sometimes supposed that in its movement around the sun, the earth always passes through exactly the same part of space, or in the same orbit, but this is not so; rather is it probably true that it never passes again through the same points of space that it once has passed through: for although in general terms its equilibrium in space is maintained, yet it is subject to multitudinous forces acting from far and near, more or less irregularly, that produce constant fluctuations or variations, and affect more or less its orbital motion. Even its diurnal motion is without much doubt, and probably without any doubt at all, lessening at the rate of from two to six seconds in a century. This may seem not to be worthy of consideration; but the truth is, speaking comparatively, this brings the time within calculation when the earth shall revolve no more; when the sun shall never again rise in glory over her eastern hills, nor set in resplendent beauty in the western horizon. As an old man with tottering footsteps and bent form visits the scenes of his childhood, and feasts on thoughts of brighter days gone by, so·may the earth, at the time we speak of, pass again over the paths of its youthful activity, and with the small remnant of life which may then be existing on its surface, repiningly drag out its existence, merely awaiting the moment when it, too, must gather up its feet in death, and return to the great whole out of which in the aeons gone by it came.

Another motion to which the earth is subject is known as the precession of the equinoxes. Generally speaking we say that the axis of the earth points to the same parts of the heavens; but this is not strictly true. Four thousand years ago the pole star was Alpha Draconis; and in about twelve thousand years it will be Alpha Lyrae. More than two thousand years ago Hipparchus discovered this phenomenon, and made allowance for it, at the same time naming it "precession"; but it was Sir Isaac Newton who discovered the cause. He found that it was owing to the inequality of the sun's and moon's attraction produced by the spheroidal form of the earth. This could never occur were the earth a perfect sphere. The result of this attraction is to change very slightly the direction in which the poles of the earth point, so that in 25,800 years a complete circle is made. This produces a change in the order of the seasons. In 6500 years we shall have the vernal equinox instead of the winter solstice; in 6500 years more, the summer solstice instead of the vernal equinox; in 6500 years more, the autumnal equinox instead of the summer solstice; and in 6500 years more, the winter solstice instead of the autumnal equinox; thus a complete revolution is made in the seasons through the precession of the equinoxes. Through the phenomenon of precession the points in which the equator intersects the ecliptic, are not stationary; but have a slow retrograde movement from east to west, making the complete circuit, as has been said, in 25,800 years. Under the combined action of the sun and moon acting on the belt of the equator, the rate of precession is subject to small irregularities. It is greatest at the solstices, and zero at the equinoxes. Between the solstices and equinoxes, it constantly decreases; while between the equinoxes and the solstices, it constantly increases. One might wonder why the rate of precession is not much greater. The explanation is partly seen in the difficulty one experiences when he tries to change the plane of a fast-moving body such as a bicycle. To change the direction of the earth's axis, not only the ring of matter around the equator must be moved, but the inertia of the whole earth must be overcome, since the ring can not move without taking the whole earth with it.

Another movement of the earth, if movement it may be called, is the change in the eccentricity of its orbit. It has been demonstrated by Leverrier and others that the eccentricity of the earth's orbit is constantly changing from one extreme to the other. Eighty thousand years ago the eccentricity is believed to have been about three tmies its present; and the average winter temperature instead of being about 39 F., as it now is, was between 6 and 23 below the freezing point. It is said by Croll that even with the present eccentricity, the earth at its aphelion is more than 14,000,000 miles farther from the sun than when at its perihelion. According to Stockwell the interval between the maximum and the minimum of the eccentricity of the earth's orbit, is about 1,450,000 years. The eccentricity passed one of its maxima 100,000 years ago; another, still higher, 200,000 years ago; another, not so high, 300,000 years; a rather low minimum, 410,000 years ago; a low maximum, 475,000 years; a very low minimum, 520,000 years; a maximum, 570,000 years; two maxima, the second 750,000 years; a very low minimum, 800,000 years; another very low minimum, 900,000 years; a high maximum, 950,000 years, and so on. In future time there will be a very low minimum in 24,000 years; a low maximum in 150,000 years; another low maximum in 250,000 years; a very low minimum in 300,000 years; a low maximum in 400,000 years; a very high maximum in 510,000 years; a minimum in 560,000 years; an extreme maximum in 610,000 years, and so on. It is sometimes said that the orbit will never have the exact form of a circle; but that after it has reached its minimum of eccentricity, it will again begin to resume its more eccentric character, until it attains its maximum of eccentricity, and that thus it will go on forever oscillating between the two extremes, without any permanent changes coming over the earth or any of the members of the solar system. On the whole, however, this is poetry. There is no room for the belief so generally held that the solar system is a permanent structure; on the contrary, we have every reason for believing that to every member of it, and to its substance as a whole, there must come a time when there shall be an end to its identity. Every body in the solar system is affecting the conditions of every other body within it, in such a way that its axial, as well as its orbital, motion must be more or less altered. In addition to the countless effects the members of the solar system make upon one another, there are innumerable bodies, known and unknown, seen and unseen, visiting our system from distances immeasurably great, from worlds unknown, which can not come to us and go from us without leaving their mark for weal or woe; and we should say for woe rather than weal. Indeed, it may certainly be said that the stability of the solar system, or of the orbital motion of any member of it, is good enough to write poetry on, and for imaginative persons to write fiction about; but speaking coolly, and standing on the cold facts of science and nature, which should be good enough for any man, we have every reason for saying that there is no ground for belief in the final stability of the solar system, or of any single member of it. As it is certain that our solar system had a beginning, so in the words of Astronomer Norton, "it must end in a chaos of cold globes at a calculable time in the future when the sun and stars shall have radiated away all their heat." Nor can we see why out of these worn out worlds there must not come what may be called the general conflagration; or, speaking more scientifically, a general impingement of all the bodies upon the central mass, to bring once more a life of youth and vigor.

The movements of our planets are much more complicated than people generally suppose. Stating them briefly these movements are:

A revolution on its axis every twenty-four hours;

A revolution once a year around the sun;

A motion of the line of apsides 11.5″ eastward annually, making a revolution once in about 112,691 years;

An oscillation of the ecliptic amounting to a few seconds every century, in all never equalling 3°, and taking many thousands of years to make one secular oscillation;

A motion of the poles, making a complete revolution in about 25,000 years;

An oscillation from a maximum to a minimum in the eccentricity of its orbit, once in about every 1,450,000 years.

The earth, as all know, is an opaque body receiving light and heat from the sun. It receives some light and heat from the moon, which the latter borrows from the sun, reflecting it to earth. The stars in their abysmal depths give us an appreciable amount of light; but so little is the heat that comes from them, that it is doubtful if it be capable of measurement. The total starlight received by the northern hemisphere of the earth is said to be about 1/6 of that received from the moon; and to be to that received from the sun as 1 is to 37,000,000.

The sun is the origin and source of all terrestrial forces. In whatever direction we look, under whatever aspect we consider it, the sun remains the one source of force and so-called life; and as he dies all energy and so-called life disappear from the face of every planet of his system. The coal in the earth, the iron in the mountain, the metal in the vein, the forest on the hillside, the flowers in the garden, the horse in the stall, the movements of the ocean and the gliding of the proud ship on its surface, the moonlight sheen on the water, the playful mirth of boys and girls, the physical strength of a Hercules, and the mighty intellect of an Aristotle — each and all come from the wonderful center of our solar system.

It may be asked, how long may one expect this state of things to be preserved. The size of the sun is definitely known, and the extent of space throughout which his heat is constantly radiated. His daily radiation is about 2,170,000,000 times that received by the earth. It is therefore not believed by astronomers that the age of the sun can greatly exceed 18,000,000 years; nor that his future can greatly exceed fifteen or twenty millions. Geologists on the other hand insist that the age of the sun can not be less than several hundreds of millions of years in order to explain known terrestrial phenomena. It is possible that both are right. On the supposition that the sun during his existence has received no heat from extraneous sources, the astronomer's figures are probably correct; but on the supposition that during this period the sun has received such heat, the geologist may be correct. That the sun in the past has received heat from outside sources seems not only possible but in the highest degree probable. Meteors are constantly to-day falling on the earth's surface; and myriads must be streaming in from all directions on the sun. But if at present this is true, how much more must it be true of the past, when the sun had not yet succeeded in drawing to itself so much of the matter that must, in the early ages, have filled the space of the solar system.

The earth moves around the sun at the rate of 30,000 metres a second. If it were to meet with a body in its course in size equal to itself, heat sufficient would be generated to dissipate both into vapor; and if a body half the size of the sun were to meet it, the shock would cause heat enough to give us our present supply for, it is said, 50,000,000 years. In the past, bodies may have frequently fallen on the sun, in this manner prolonging his energies.

The exact time during which our system has been in such condition as to permit our earth to be the seat and abode of so-called life, can not be definitely stated; but so much may certainly be said: there is a limit to the duration of the present condition. As it had a beginning, so must it have an end. Then cometh a momentous change, when the sun shall give up his sceptre to Chaos, who shall once more reign supreme, until the time when a new cosmos shall be born; and the substance of beautiful Earth shall be there to take part in the general rejoicing.

CHAPTER VIII

THE EARTH CONTINUED

WE NOW study the earth from closer relations than in our preceding work. There we examined it more as a whole in its relation to the cosmos of which it forms a part. Here we examine it as it were anatomically, individually, and in its relation to us. It is the science of geology that exposes the earth in this manner to our view. He who has no knowledge of this science, can have but a very imperfect idea of our mother Earth; nor is there, perhaps, any study which effects greater changes in our views, or tends more to give us a correct knowledge of so-called creation as a whole. In the words of Huxley: "There is no better study fitted than that of geology to impress upon men of general culture that conviction of the unbroken sequence of the order of natural phenomena throughout the duration of the universe, which is the great and perhaps the most important effect of the increase of natural knowledge."

The history of our earth began at the moment it was completely separated from the parental nebula. Up to that time it was only being generated as the pine is in the beautiful cone seen waving on the tree-top; but as soon as it was set free from the nebula, it was as the cone set free from the tree and buried in the soil: it then began its own independent career (as far as one world can be said to be independent of another) and one whose wonderful history proves clearly enough how great was the store of energy it had received from the parental fiery mist. As one when looking at the beautiful rose does not search outside of earth and air for the constitutent elements entering into its being, so does one not search outside of the cosmos for the forms of life and activity he may find in it. In the rose we see nothing more than a gradual change from root to petal, a slow substitution of one form for another according to the laws of growth. In the words of Huxley: "There can be no doubt that the existing fauna and flora is but the last term of a long series of equally numerous contemporary species, which has succeeded one another by the slow and gradual substitution of species for species, in the vast interval of time which has elapsed between the deposition of the earliest fossiliferous strata and the present day."

It is perhaps very difficult if not impossible to form anything like a correct idea of the original temperature of the earth. It would seem that it must have been at least equal to that of the sun to-day. Says Dana: "There must have been a first era, after that of the original nebula, in which the earth was a globe of molten rock, like the sun in brightness and nature, enveloped in an atmosphere containing the dissociated elements of the future waters and whatever else the heat at the surface could throw into a state of vapor." Since the sun has been losing its heat for many millions of years, it is probable that the original temperature of our earth was much higher than the present temperature of the sun; but in considerations so vast, it is foolish to expect anything more than an approximation to the truth. A large globe like the earth does not quickly part with its heat. Helmholtz considering the rate at which the earth loses its heat, comes to the conclusion that it must have been three hundred and fifty million years in passing from 2000° to 200° C.; and Dana holds it must have been scores of millions before the earth was cool enough for the abode of so-called life. We shall probably under-estimate rather than over-estimate the time, if we set down the age of the earth at the first appearance of so-called life, as about 400,000,000 years. This in geology is called the Archaean Time. That there was such an era, no one can doubt; but it comes to us as a voice out of the profound and dark eternity. It was the age of chaos; an age in a certain sense without form and void. The duration of the Archaean Time is held to have been greater than that of all the rest of earth's recorded history. After this the earth passed through its period of childhood called the Paleozoic Time. Dana estimates this period at about 36 million years. Then came its period of youth called the Mesozoic. This by Dana is reckoned at about 9 million years. After this came its period of maturity called the Cenozoic Time, which Dana sets down as, up to the present, 3,000,000 years. The earth is now probably in her decline.

The periods we have here given are vast; but time is long. Perhaps no better evidence is found of the vastness of time than the manner in which coral reefs grow. It is believed that the rate of growth of a coral reef can not exceed one-sixteenth of an inch a year; and we know that there are coral reefs not less than 2000 feet thick. From this it follows that for the building of some such reefs, there must have elapsed not less than 384,000 years. Some geologists claim that thousands of millions of years have passed since the appearance of life on the globe. Sir William Thompson, basing his estimate on other calculations, has set down the time since the appearance of life at about 100,000,000 years. In all calculations of time, geologists in general claim much more than astronomers and physicists are willing to admit. Yet Mr. Croll, an eminent Scotch authority, and who is very greatly opposed to the long estimates of the geologists, says: "It is, in fact, impossible to form an adequate conception of the length of geological time. It is something too vast to be fully grasped by our mind. Geological phenomena tell us most emphatically that these periods must be long";

but he thinks we should be satisfied with Sir William Thompson's estimate of the age of the earth's crust, namely, 100,000,000 years. Haeckel thinks that there is no reason whatever for limiting geological time, and that it is much more philosophical to assume periods that are too long than periods that are too short, holding that "every process of development is the more intelligible the longer it is assumed to last. A short and limited period," he says, "is the most improbable."

We may say in passing that it is to Charles Lyell, the eminent English geologist, that geology owes its thanks for its establishment upon its present sound and philosophical basis. Not until his publication, in 1830, of his Principles of Geology, was geology worthy in any sense of being called a science. Says Haeckel: "Lyell thus demonstrated a continuous and uninterrupted connection of the whole history of the earth, and he proved it so irrefutably and established so convincingly the supremacy of the existing causes, that geology in a short time completely renounced Cuvier's hypothesis."

Apart from the nebular hypothesis we have other evidence of the original fiery condition of our earth. Our hot-springs, geysers, and volcanoes all give proof of the earth's present internal heat; and it can not be but that it was in times gone by much hotter than it is to-day; for we all know that the tendency of every hot body is to part with its heat, until it raises every surrounding body to its own temperature. Thus the earth has been for millions of years parting with its heat. The fact that it has parted with it so slowly is explained by the fact of its size and crust. Up to the formation of its crust, radiation must have been enormous; but after this time, it rapidly fell in amount, its crust acting like a heavy woolen coat on the human body; it has served to keep the heat within.

The earth's interior is in a molten state. By this it must not be supposed that we mean a less dense condition than its surface; on the contrary, the earth's interior is incomparably more dense than any terrestrial substance exposed to our gaze, and this too because of the immense pressure to which it is subjected, a pressure believed to be not less than 45,000,000 lbs. to the square inch. Another proof of interior heat is the regular increase of temperature we meet with in descending into the earth. Indeed, so well has this fact been known that the early Christians taught that hell was in the centre of the earth. In the heart of the earth where the fires rage most fiercely, and the supply of fuel most abundant are the regions of the damned. Says Tertullian writing early in the 3rd century: "By ourselves the lower regions of hell are not supposed to be a bare cavity, some subterranean sewer of the world, but a vast deep space in the interior of the earth, and a concealed recess in her very bowels."

When one has descended but a comparatively little depth, he finds a constant temperature. There no change is felt. The summer sun may scorch, the winter cold may freeze, and the cyclone may devastate a whole state; but here all is calm, all is peace, all is the same. In the boring of Artesian wells we have other proof of internal heat. Here the general rate of increase is 1° F. for every 50 or 60 feet of additional depth. Somewhere between 20 and 30 miles below the surface, the earth must have a temperature sufficient to fuse iron. The thickness of the earth's crust is variously estimated by different scientists; the judgments of scientists as a whole will fall within the estimate we have just given. Humboldt says that at a depth of about 21 miles a heat prevails great enough to melt granite; Elie de Beaumont gives 21 miles as about the thickness of the earth's crust; and according to Bishot the thickness of the unmelted strata of the earth is about 24 miles; Daniels, quoting Osmond Fisher, gives us from 25 to 30 miles as its thickness; and Newcomb, in speaking of it, says: "If we trace to past times the conditions which must have existed in order that the increase might show itself at the present time, we shall find it almost certain that a thousand years ago, the whole earth was red-hot at a distance of 10 or 15 miles below the surface; because otherwise its interior could not have furnished the supply of heat which now causes the observed increase. This being the case it is probably red-hot still, since it would be absurd to expect a state of things like this to be merely temporary. In a word we have every reason to believe that the increase of 100° a mile continues many miles into the interior of the earth. Then we shall have a red-heat at a distance of 12 miles, while at a depth of 100 miles, the temperature will be so high as to melt most of the materials which form the solid crust of the earth. We are thus led to the theory, very generally received by geologists, that the earth is really a sphere of molten matter surrounded by a comparatively thin solid crust, on which we live." This crust gradually merges into the condition of the interior and floats, as it were, on the molten magma.

As the earth has always in the past been losing its heat, so is it at present. The amount of this loss has been calculated by Thompson to be enough to melt annually a complete covering of ice .0085 millimeters thick, to water at 32° F., or to melt no less than 777 cubic miles of ice to the same state. Knowing these things one cannot fail to see that the earth is most surely parting with its heat.

Not much is known of the Archaean age; for long as that age was, it was yet the infant age of the earth. During this vast period whatever biographical records the earth might have left us, would probably in general be destroyed by the great metamorphism of this age. The forces that changed sandstones into quartzite, clays into schists, gneiss, and granites, and limestone into marbles, could not be expected to leave us much remains of whatever vegetable and animal life may then have been on the earth; but from the fact that among the vegetable remains of the succeeding age, the lower Silurian, we find evidences of only the lowest forms of vegetable life, it is reasonably believed that only the lowest forms of plants existed in the Archaean age. Among plants, sea-weeds, lichens, and mosses; and among animals, some protozoa such as the rhizopods are believed to have been prevalent. Some scientists hold that we have evidence of the existence also, in the Archaean age, of some annelids or sea-worms. We think it probable that the lower forms of life were abundant in this age; but that nearly all traces of them have been effaced by the great metamorphism to which the rocks of the Archaean age were subjected.

When we speak of the Archaean rock, it must not be supposed that the primeval earth-crust is meant; for of this crust nothing whatever is known or can be. The Archaean rocks have ben stratified, like rocks in general. They are therefore but consolidated sediments which must have originated in the pounding, grinding, or reduction, by the forces of nature, of still older rocks, the first rock-crust of the earth. As we have said the age of this formation is vastly greater than that of any other. The depth of this formation in Canda is said to be not less than 40,000 feet. In this strata the largest known beds of iron ore are found, such as those of Lake Superior, Sweden, New Jersey, and Missouri; and graphite also which is considered a form of coal, is found in very large quantities in the rocks of this age.

This age must have been one of profound quiet. The ocean reigned supreme; and it was the chief worker in building up the strata. When we think at what a slow rate a quiet body of water deposits sediment, we can form some idea of the vast time of this age, knowing that it was in this manner the ocean deposited a depth of not less than from 40 to 50 thousand feet of solid rocks.

The next age is the Paleozoic. It is divided into three periods, the Silurian, the Devonian, and the Carboniferous.

In the rocks of the lower Silurian no evidence is found of the existence of any higher forms of plant-life than seaweeds and club-mosses; of animal life, however, we have more abundant remains; they were all marine invertebrata, belonging to the four sub-kingdoms, Protozoa, Mollusks, Radiates, and Articulates. The Protozoans were represented by Rhizopods and Sponges; the Radiates, by Graphtolites, Crinoids, and Corals; the Mollusks, by all kinds of species from that of Bryozoans to that of Cephalopods; and the Articulates, by Worms and Crustaceans. Of Crustaceans the Trilobites were so abundant and various, that the Silurian age is really characterized by them. In all probability the sea was no less full of life in the Silurian age than it is to-day. In the passing out of the Silurian age fish began to make their appearance, or a kind of fish; for in the beginning the representatives of the higher forms of life we have with us to-day were quite different from their descendants: they were all, as it were, monstrous forms between what had passed away and what were to come. The evidence of the existence of fishes in England in the latter part of the Silurian age, is considered certain.

The maximum thickness of the Silurian rocks is set down as at least 25,000 feet; and the time of this rock formation is supposed to have been not less than one-half of all geological time from the end of the Archean age to the present day. The rocks consist chiefly of limestone, marble, sandstone, shales, conglomerates, and coal.

After the Silurian came the Devonian age. During this time there was a great increase in the character and amount of plant life. Abundant evidence is found of the existence of the higher forms of Cryptogams such as Lycopods, and of the lower forms of Phenogams such as Conifers. Indeed, we find in this age evidence of the existence for the first time of a true forest-vegetation. The appearance of land plants seems sudden; but there were in the Silurian age signs of the existence of their less developed progenitors.

In this age vertebrate animals first appeared in America, under the form of fishes. They must have existed under other forms in the preceding age, for there is nothing without a progenitor; although complete evidence of such existence is wanting, because of the reason we have already given, more especially metamorphism. As in the beginning of every new form, these fishes were strange creatures. At first their size was small and their numbers few; but in both directions their increase was most rapid. So full were the Devonian seas of these strange fishes that the Devonian age is sometimes called the age of fishes. These fishes were called by Agassiz Reptilian fishes, a name by no means inappropriate. Says one well known geologist: "They all have reptilian characteristics united with fish characteristics,—they are all connecting links between fish and reptiles. It is a general law that the first introduced examples of any family, order, or class, are not typical forms of that family order or class, but intermediate forms or connecting links with other families, orders, etc. From such intermediate forms or connecting links have been afterwards developed the more typical forms. To illustrate: The first fishes were not typical forms, but connecting links between fish and reptile, and from this intermediate form, as from a trunk, true fishes and true reptiles were afterwards separated and developed as branches." (LeConte.)

It is not until the Devonian age that we have any evidence of the existence of insects. These animals depend for their existence largely on land vegetation; and this did not exist to any extent before the Devonian age. These insects, however, were not true insects; they were connecting links between cockroaches and dragonflies. Such as they were, they were fully developed; and therefore they must have had their origin in the age or ages preceding, although we have but imperfect vestiges of such antecedents. These quasi-insects were of immense size, one of them measuring 5 inches from tip to tip of wing. They belonged to those insects whose larvae live in water, and are found in moist places. Because of this their remains stood a good chance of being preserved; therefore we have them to-day as fossils. One species is supposed to have possessed an organ similar to that of the cricket, a stridulating apparatus. Dawson therefore remarks that "the trill and hum of insect life must have enlivened the solitude of the strange old Devonian forests." Apart from insects no other winged creature is believed to have existed during the Devonian and Carboniferous ages.

In Devonian days but little dry land existed over the vast region now known as North America. To a great extent it was one vast continental ocean with a little dry land here and there. In place of the Rocky Mountains and Appalachians there were a few islands, reefs, and shallow waters. The Green Mountains were above the sea, although they had not as yet attained their present height. The Hudson River is supposed to have been running in those days; as well as such northern streams as the Ottawa; and the Connecticut and perhaps other New England rivers at that time began their existence; as also the St. Lawrence, at least above Montreal.

The temperature of those days was much more equal than now. Indeed it is supposed that there was but little difference between the climates of the Temperate and Arctic Zones.

Of the Devonian age the maximum thickness of the rocks is set down as about 14,400 feet; and its duration is thought to have been no more than one-quarter that of the Silurian age.

At the close of the Devonian a great change came over the face of the earth. There came up a generation of magnificent forests. This period is called the Carboniferous age. Gymnosperms are represented by Conifers and Cycads; Crytogams by Ferns, Club-mosses, and Equisetae. The vegetation of the period was generally of a rank but tender nature, quick of growth and easily destroyed. It might, as it were, be raised in a day and laid low in a moment. One surging blast would level a forest, while the rankness of the soil and the warmth of the atmosphere and ground, would soon supply another.

This was the character of the vegetation of the period. It lived fast and died early. Thus generation after generation they quickly appeared and as quickly were buried in the sepulchers of their predecessors, forming large beds of decaying vegetation. Some of these beds were changed into coal which is preserved in vast quantities in different parts of the world. It is from this fact that this period is called the Carboniferous age.

In this age the fresh-water and land shells which appeared in the Devonian, became more abundant; the varieties and numbers of insects greatly increased. Scorpions, beetles, cockroaches, spiders, centipedes and dragonflies, have left their vestiges in the rocks of this period. In this age were also introduced amphibians. This is considered a great step, for they were the first air-breathing vertebrates. It is not believed that any birds or mammals existed as yet. Amphibians, as we all must know, are a kind of tertium quid, that is they are creatures between fish and reptile. These were very numerous and many of them were of a frightful character, and enormous dimensions. They were not of the modern type, (frogs, toads, newts, etc.) for they had the scales of the Ganoid fishes and teeth with the labyrinthian internal structure of Ganoid teeth. The Archegosaurus was one of these. It was an animal two or three feet long covered with plates and scales, with permanent lungs and gills, and having for legs a kind of fins. It is considered a real connecting link between the Ganoids and the Amphibians.

During this age the Appalachian chain was formed. It is from this fact that in America it is sometimes called the Appalachian Revolution. The maximum thickness of the rocks of this period is set down at about 16,000 feet, and its duration as about equal to that of the Devonian age.

The time which follows the Carboniferous age is called the Mesozoic. Sometimes because of the great number and variety of reptiles that lived during the period, it is called the Reptilian Age. For these the preceding age had prepared the way. The dense vegetation, vast marshes, wide-extending bogs, and shallow waters, were fitting retreats for these monsters which ruled the earth both on sea and land. During this age the animals whose rule was becoming evident in the Carboniferous age, attained their maximum size and sway. Never before were reptiles so numerous, so large, so terrible, or so highly organized. Other marked features of this age are the culmination of Cephalopod Mollusks among animals, and of Cycads among plants. To this age must be referred also the introduction of mammals and birds; of Teleost fishes and Dicotyledonous trees. The reptiles were of three kinds, marine Saurians, land Saurians, and air Saurians. The marine Saurians were fish-reptiles, the land Saurians were lizard-like creatures, very large, in fact the most unwieldy and monstrous that have ever been on earth. They were a connecting link between the marine Saurians and the air Saurians. The air or winged Saurians were most wonderful animals: "They combined the stout body with keel breast-bone, the long flexible neck and beak-like jaws of a bird, with the long arms and membranous flying-web of a bat and the essential characteristics of a reptile. In some cases they had a short aborted tail like a bird, but in other cases a long tail with vertical expansion at the tip, which was used as a rudder in flying." As these reptiles had bird characteristics, so still more evidently had the birds of this age the characteristics of reptiles. The fossil of the oldest known bird is of this period. It was discovered in 1862, in Bavaria, and is called the Archæopterix. This bird had a reptilian tail 11 inches long and 3½ broad with 21 joints; with a row of feathers along each side, a pair to each joint. It had also socketed teeth and two free fingers which were armed with claws. Wide apart as reptiles appear to-day from birds, the student by tracing his steps along the lines of their existence, finds these lines coming closer and closer together until they meet in a common point. He then finds neither reptile nor bird, but a monster between the both. And thus it is with all forms of life on earth.

As specimens of marine Saurians we might give the Ichthyosaurus, Plesiosaurus, and Pliosaurus. The Ichthyosaurus was a monstrous animal from 30 to 40 feet long with paddles like a whale, short neck, thick body, long head and jaws, striated teeth, eyes about 15 inches in diameter, and hundreds of conical teeth. This animal has been found in such perfect preservation that it is possible to tell the nature of its last meal. The Plesiosaurus was from 25 to 30 feet long, with long neck like a snake, with 20 to 40 biconcave vertebræ, small head, short body, and paddles. The Pliosaurus was another Saurian. It was from 30 to 40 feet long, and was allied to the preceding.

As specimens of Dinosaurs or land Saurians, we give the Megalosaur, the Iguanodon, and the Atlantosaur. The Megalosaur was from 25 to 35 feet long. It had hollow bird-like limb bones; and it could wade in the water, or walk on its hind legs on the land like a bird. Some had only three toes on their hind-feet, and thus made bird-like tracks, and they had very bird-like characteristics about the ankle joint. The Iguanodon was an animal 30 feet long. It had the habits of the hippopotamus, and enormous bulk. The femur, or thigh-bone, was 33 inches long; and the humerus, 19. The Atlantosaur was 120 feet long. Some were bird-footed, some reptile-footed, some beastfooted. A thigh-bone has been found which measured no less than 8 feet.

We have said that mammals were introduced in this age. These early mammals, however, were peculiar; they were in fact reptilian in character, or marsupials. To-day they are almost wholly confined to Australia. In the middle of the Reptilian age these animals apparently lived in every part of the earth. One peculiarity of such animals is that their young are born in very imperfect state. Nor were these early marsupials as the marsupials of to-day; they were nearer reptiles; they were marsupial insectivores.

In this age the first known Angiosperms, ordinary hard-wood trees, made their appearance, although their species were different from these of to-day. Oaks, maples, willows, dogwood, sassafras, hickory, beech, walnut, sycamore, laurels, myrtles, etc.—all graced our earth in those far-off days. The sudden appearance of these may seem somewhat strange. The truth is although their remains appear suddenly, the plants themselves did not. Without a doubt if some of the leaves of the book which the earth has written, were not missing, there would be a full description of every kind of plant connecting the Angiosperms with the flora of the Carboniferous age.

During the Reptilian age insects existed in vast numbers, and in a very high state of development; even the honey-bee might have been seen gathering honey all the day, and storing it up for winter use.

At the close of this period the Sierra Nevada, the Humboldt ranges, the Wasatch, and the Uintah Mountains rose above the waters, as a result of gradual upheavals or sudden up-risings. It was during this age that the great chalk formations were deposited. At the close of the period there is supposed to have been an unusual destruction of existing species. The passing away of existing species and the introduction of new ones, are characteristic of every period; but it is especially characteristic of the close of the Reptilian age. Such great destruction may have been a result of the changes of level, following the disturbances at this time.

From the Reptilian age or Mesozoic time we pass to the Cenozoic time or Mammalian age. This age is divided into two periods: the Tertiary and Quaternary.

The characteristic of this age is the culmination of mammals and the first appearance of man. There were mammals of immense size which in numbers and power now took the place of the reptiles of the preceding age. Mammals are found in the very lowest beds of the Tertiary age. There were herbivores, carnivores, and primates or monkeys; but these were not distinctly separated then as now one from another. They may be called generalized types. Even the first monkeys were not exactly as they are today; and they are therefore called prosimiae or progenitors of the true monkey.

As specimens of mammals of the earliest part of this age, we give the Coryphodont. It was a huge animal having a very small brain, plantigrade feet, slow heavy movement, and very uncouth appearance. The Loxolophodon was another animal of this age, of slow gait, tremendous size, peculiar head, having three pairs of horns and huge tusks. Its head is held to have been five feet long. The progenitor of the horse is found in this age. It was at first a very small animal with three hoofed toes on the hind-feet, and four perfect hoofed toes and an imperfect one on the fore-feet. Later in this age, the same animal is found, first without the imperfect toe, and finally with only one toe, like our present horse. The names of this animal, corresponding to the times in which it is found, are: the Eohippus, Orohippus, Mesohippus, Miohippus, Protohippus, Pliohippus, and Equus. Thus is the perfect development of this animal left us in the pages of earth's history; and thus does nature bring about her changes.

In the beginning it was not much larger than a fox; but with every variation it increased in size. In this age are found the beginnings also of the deer, the camel, the dog, the cat, and the rhinoceros; although they were far different from what they are to-day. At this time lived the Great Elephant; oxen of gigantic size; the Great Elk, 11 feet high and 10 from tip to tip of horns; the cave bear; the lion; the tiger; the Mastodon, an animal more than twice as large as our present elephant; and the Diprotodon, a kangaroo as big as an ox. In some period of this age, probably in the Quaternary, appeared man. His remains are frequently found in caves with the cave bear. He was very low in the scale of life, scarcely knowing how to make use of his hands or his head; and did not dare at first to contend with the animals around him. Finally he began to make stone instruments, arrow heads, spears, etc. Little by little as his brain developed by the use of it, he was enabled to overcome the fiercer animals around him; although it is doubtful if any animal was, at heart, fiercer than early man. But from the fact that his development had been in a different direction he was physically unable to contend with animals which had been constantly developing in the direction of physical strength, and destructive powers. Man therefore had to search after other means of defense to make up for his physical disability: he had to search after or to make instruments, and learn to use them. Thus was necessity the cause that developed his brains until man became the man of to-day. Says Dana: "The animal kingdom began with the Protozoans, then followed Radiates, Mollusks, and water Articulates. It included fishes and the lower vertebrates in the Silurian; and amphibian Reptiles in the commencing Carboniferous. Which each period the progress was upward toward a fuller and higher display of the system of life."

It is impossible to say when man made his first appearance. It may have been 100,000 years ago; it may have been much more; it may have been less. But we must believe that man has developed gradually, and step by step, out of the lowest forms of life, and more immediately out of ape-like animals. This doctrine is an inseparable part of the theory of universal descent and development in general; and it is so recognized by all thoughtful students of biology and zoölogy. Says Huxley: "Thus whatever system of organs be studied, the comparison of their modification in the ape-series leads to one and the same result, that the structural differences which separate man from the gorilla and chimpanzee are not so great as those which separate the gorilla from the lower apes." Huxley classes Man, Apes, and semi-Apes all in a single order, and calls it Primates, dividing this order into seven families. We believe he is correct in so doing.

In conveying an idea of the development of life on the earth, it is doubtful if we can do better than give the following from Haeckel: "We may imagine the whole world of organisms as an immense meadow which is partially withered, and upon which two many-branched and mighty trees are standing, likewise partially withered. The two great trees represent the animal and vegetable kingdoms, their fresh and still green branches the living animals and plants; the dead branches with withered leaves represent extinct groups. The withered grass of the meadow corresponds to the numerous extinct tribes, and the few stalks still green to the still living phyla of the kingdom of Protista. But the common soil of the meadow from which all have sprung up, is primeval by protoplasm."

When we look for absolute proof of man's orderly development, it is true that some connecting links are wanting; but this is found to be true in a degree also of other animals whose orderly development is not doubted, and even of many vegetables. Indeed, such absence of connecting links should be expected. For when we know that every age witnessed the constant disappearance of some species and the appearance of others, it is almost to be wondered at that we possess so many proofs of man's orderly development as we have. We may be sure that man came up as it were through great tribulation; that little by little the man that was to be, assumed the erect position, coming up from the lowest forms of life; that little by little he acquired his organs of speech, and little by little his superior cranial development. Says Haeckel: "The certain proof that primeval men without the power of speech, ape-like men, must have preceded men possessing speech, is the result arrived at by an inquiring mind from comparative philology, and especially from the history of the development of language in every child as well as in every nation."

In the early part of the Cenozoic age the ocean lost much of its domain, for it was then that the following mountains appeared above the water: the Alps, the Pyrenees, the Apennines, the Himalayas, the Andes, and the Rocky Mountains.

CHAPTER IX

THE MOON

OF ALL the heavenly bodies the moon is undoubtedly, with the exception of the sun, the most interesting globe to the inhabitants of the earth; and well it should be, as none other performs so great benefit. No other heavenly body has been the subject of so much poetry and song, nor has the aid of any other been so frequently sought. The wanderer, the traveller, the lost one, and the mariner have all rejoiced in her timely beams; and the peasant as well as the soldier has been glad at being able to complete his task "by the struggling moonbeam's misty light." It is indeed humanity's lantern, whose rays are ever faithful and true, never failing to guide our erring feet, or to lead the toiling laborer home.

Comparatively the moon is a very small body. It is a most mountainous world, its surface being literally covered with peaks and cones from one to sixty miles in diameter. About forty lunar peaks are higher than Mont Blanc. The highest mountain, called Leibnitz, is not less than six miles high; and there are said to be at least sixty thousand craters on the moon's surface, some of which are not less than 100 miles across. Some astronomers affirm that there are evidences of change on the surface of our satellite; but it is not believed in general that there are sufficient grounds for making such assertion. The valleys and holes seen on the moon are far greater than any corresponding ones on the earth's surface. Some irregularities appear like cones of volcanoes; and frequently down in the very depths of these hollow cones, may be seen the tops of much smaller ones similar to those frequently found in earthly volcanoes. There are still larger cavities called "bulwark plains." The diameter of these is often more than 100 miles, and all along their bottom arise numerous hills or cones. Still larger tracts are seen not so rough as the surface in general; and having a bluish color. These views used to be called seas, although they are evidently too full of inequalities to be fluid; and they are therefore not believed to be seas to-day. Besides these black depths and horrid heights there are parts that appear like mountain ranges, and such they are believed to be. The great crater Copernicus has walls 50 miles in diameter, and it rises to a height not less than 13,000 feet; and there are plains from 40 to 150 miles in diameter, with great walls all around them. Almost at the moon's centre is the great crater Triesnecker. West of this remarkable crater there are cavernous cliffs of great width and not less than 300 miles in length.

It is not believed that the moon has any atmosphere: the most delicate tests fail to reveal any sign of it. When a star is seen to disappear behind the moon, the disappearance is sudden. In the twinkling of an eye it goes into intense darkness. If there were an atmosphere, the star when it reached the moon would appear to be displaced in a direction from the moon's centre; but no such displacement has ever been recognized. The light of the moon has been carefully examined also with the spectroscope to see if there could be found any absorption lines, such as would be produced if the sun's rays passed through a lunar atmosphere; but such tests fail to show the least sign of an atmosphere. In fact the spectrum of the moon is the same as the spectrum of the sun. The water once on the moon is supposed to have been vaporized into atmosphere; after which gradual dissipation took place because of the inherent motion of the particles of gases composing such atmosphere, and the small attractive force on the moon, being about one-sixth that on the earth. By some it is believed that a similar explanation solves the riddle why there is no free hydrogen in the earth's atmosphere. Hydrogen being very light and having a very great vibratory motion, has overcome the attraction of the earth, and gone into space.

It must be a very strange world without moisture or air; yet we have every reason for asserting that there is neither on the surface of our satellite. It would seem, therefore, since there is neither ocean, sea, river, vapor, nor air on the moon, that what is called death must have supreme dominion there. Yet we may be sure that nature is capable of producing life and intelligence infinitely more varied than we know anything of; and as with us life ever seeks to adjust itself to its environments, it would be rash in us to hold that nature is not able to produce such life as might find a home even in the moon. All we can say is that in a world where there is no atmosphere, where the rivers flow not, and the rains descend not, life such as we know could not exist.

The moon is a satellite, and moves around the earth while at the same time making its annual circuit of the sun. It moves in an ellipse one of whose foci is at the earth; and its orbit has an eccentricity of one-fifteenth, which is about four times that of the earth's orbit. Its greatest distance from the earth is to its least as 8 is to 7. When nearest the earth, it is said to be in perigee; when farthest, in apogee. It revolves around the earth in 27.32 days, and on its axis in the same time. It therefore always keeps the same side turned toward the earth. Its revolution around the earth is at the rate of 2288 miles an hour; and around the sun, at the rate of 66,000 miles an hour.

Although the moon keeps the same side always turned toward the earth, as the earth revolves around the sun, and carries the moon along with her, the moon is subjected to a great diversity of temperature. With a cloudless sky, and no atmosphere the surface of the moon must be frightfully heated during the long day, which must equal fourteen of ours; and during the long night, equally long compared to ours, it is said that the temperature must fall certainly as low as 200° below zero. Lord Ross declares that the temperature of the lunar surface, at the time of full moon, must be far above that of boiling water. There are those, however, who hold that because of the lack of atmosphere no part of the moon's surface is ever heated above the freezing point of water.

The moon's orbit is inclined to the plane of the ecliptic 50° 8′ 44″. This inclination prevents an eclipse occurring at every lunar conjunction.

A revolution of the moon is performed in different times with reference to the sun, the fixed stars, and the first point of Aries. With reference to the sun it is performed in 29 days 12 hours 44 minutes 2.87 seconds; with reference to the first point of Aries, in 27d 7h 43m 4.614s; and with reference to the fixed stars, in 27d 7h 43m 11.461s. The difference between the first and third of these periods is due to the advance of the sun, or speaking more correctly, to the revolution of the earth around the sun; for during the moon's revolution around the earth, the latter will have moved through space around the sun 27 degrees, and in order to make this up the moon will have to journey 2 days and 5 hours longer; for it will take the moon this long to pass over an arc of 27 degrees. The difference between the second and third of these periods, is owing to the small regress of the first point of Aries in 27 days — about 50.2″ a year.

The plane of the orbit of the moon not being parallel to the plane of the ecliptic, it must necessarily cut the latter in two places. These points of intersection are called the moon's nodes. When the moon passes from the south to the north side of the ecliptic, it is said to be in the ascending node; when it passes from the north to the south side, it is said to be in the descending node. When the moon is between the earth and sun, it is said to be in conjunction; when the earth is between the moon and sun, the moon is said to be in opposition. The points of conjunction and opposition are called the syzygies.

Since the surfaces of bodies are as the squares of their radii, it follows that the earth's surface is about thirteen times that of the moon; and as the volumes of bodies are as the cubes of their radii, the volume of the earth must be about 49 times that of the moon. But since the earth's specific gravity is 5.67 and that of the moon but 3.4, it follows that the mass of the earth is no less than 81 times that of the moon. From this we see how the earth rules the moon in its orbit, having no less than 81 times the attractive power. It was this power of the earth to hold the moon in its orbit that Sir Isaac Newton discovered in 1665, when only twenty-three years of age. The true diameter of the earth, however, not being known at that time, he came to an erroneous conclusion. He therefore postponed his calculations until a truer estimate of the earth's diameter was made by Picard of France, when he renewed his former calculations, and discovered that the force which keeps the moon in its orbit, is the same as that which brings a stone to the ground.

A body falls to the earth 16 feet the first second of time; in one minute 16 multiplied by the square of 60. But inasmuch as the moon is distant from the earth just about 60 times the earth's radius, it follows that the force of the earth's gravity must there be reduced the square of 60 times. It was thus that Newton proved that the moon was deflected in her orbit by the earth's attraction, 16 feet in one minute of time.

To some it may appear strange why a body can be forever falling toward another, and yet approach no nearer. The following may help such to a better understanding: Suppose a body, such as a rifle ball, was projected over the earth from some high tower, at the rate of 5 miles per second. At the end of the first second, by the law of gravitation, the ball should be 16 feet nearer the earth; but the earth has fallen away this much through its rounded surface. At the end of the second the ball will have fallen in its flight 48 feet toward the earth; but in ten miles the earth's surface falls away this much for the reason just given. Thus the ball can keep on, if there be no atmospheric resistance, and in about one hour and twenty-four minutes it will have passed around the earth without coming any nearer. It will now be a little world moving around our globe, and will keep on forever, unless interrupted by some extraneous force or forces. It is thus that the moon keeps on in her orbit around the earth.

Since the discovery by Sir Isaac Newton of the law of gravitation, science has had, as it were, tools to work with: it has unlimited faith in the laws that govern the universe, and the law of gravitation is one of these universal laws. "The theory of gravity so exactly accounts for all the physical phenomena of the solar system, that it is impossible it should be false; and although we can not understand its nature or its essence, it is as unreasonable to doubt its existence as to doubt the existence of animate beings, because we know nothing of the principle of life." (Robinson.)

The sixteen and one-twelfth feet which a body falls to the earth in one second of time, is the measure of the earth's attraction; and this earth-force may be used as a unit when measuring the attractive power of the heavenly bodies above us.

We have stated that the moon always presents the same side toward us, and this is true; but because of certain irregularities in the movements of the moon, we are enabled to get a glimpse of a little more than one-half of its surface. Says Sir John Herschel, "The moon's rotation on her axis is uniform; and since her motion in her orbit is not, we are enabled to look a few degrees round the equatorial part of her visible border, on the eastern or western side, according to circumstances; or in other words, the line joining the centres of the earth and moon fluctuates a little in its position from its mean or average intersection with her surface to the east or westward. And moreover, since the axis about which she revolves is not exactly perpendicular to her orbit, her poles come alternately into view for a small space at the edge of her disk. These phenomena are known by the name of librations. In consequence of these two distinct kinds of libration, the same identical part of the moon's surface, is not always the centre of her disk; and we therefore get sight of a zone of a few degrees in breadth on all sides of the border, beyond an exact hemisphere."

The names of these librations are:
Libration in Longitude,
Libration in Latitude,
Diurnal Libration.

The libration in latitude arises from the fact that while the moon rotates uniformly on its axis, it revolves in an elliptical orbit, with unequal angular velocity. Near the apogee, where the moon by the laws of motion moves most slowly in her orbit, she revolves on her axis more than 90°, although passing over no more than 90° round the earth; and this uncovers a little of her hemisphere on the eastern side. Again, when near the perigee, where by the laws of motion the moon moves most rapidly in her orbit, she makes less than one-fourth of her axial rotation, while passing 90° round the earth; and thus she reveals a little of her hemisphere on the western side. It is therefore owing to the elliptic orbit of the moon that we have sight of a little more than one-half of her hemisphere; for if her orbit were circular, there would be no libration in longitude.

The explanation of the moon's libration in latitude is similar to that given to show why at one time of the year the north pole of the earth is inclined to the sun, and at another time the south pole. As the moon's equator is a little inclined to the plane of her orbit, her north and south poles are alternately a little exposed to us. The mean value of the inclination of the moon's equator to the plane of her orbit, is 6° 39′. If the earth's equator and the plane of her orbit were in the same plane, there would be no change of seasons, such as we have to-day; and if the moon's equator were in the same plane as the plane of her orbit, there could be no libration in latitude.

The explanation of the diurnal libration is this: When the moon is on our meridian, we see her, as if it were, from the centre of the earth; but when she is in our horizon, we look over her surface from a position as much higher, as the surface of the earth is distant from its centre, that is, about 4000 miles. This enables us to see a little over her western limb at rising, and over her eastern at setting.

Notwithstanding the fact that the moon is controlled in her orbit by the earth, we must not suppose that the sun is an idle looker-on. Such a stupendous body may smile at the puny efforts of the earth to rule the moon, and quietly abide his time, knowing that finally all must bow the knee to him. As the central body of the solar system, the sun's mass is equal to 700 times that of the combined masses of all the members of his system; and therefore he can haul or draw 700 times more than all the planets and planetoids put together. Hence all movements are principally controlled by the sun.

The sun has a very disturbing effect upon the relations of the earth and moon. When the moon is in conjunction, the sun's atraction is greater on her than on the earth, as the squre of 387 is greater than the square of 386. This diminishes somewhat the tendency of the moon to the earth. In opposition the moon is farther from the sun than is the earth, and therefore his attraction for the earth is greater than it is for the moon, in about the same ratio as before. This again lessens the moon's tendency to the earth. At the syzygies the moon's gravity to the earth is thus diminished; and this diminution is reckoned as equal to one-ninetieth of the whole.

In quadrature the force of the sun is exerted on the moon in a line a little oblique to that in which he acts upon the earth. Because of this, to a very small degree, the sun tends to help the earth in drawing the moon earthward. This assistance is computed to be just about one-half of that which he exerts against the earth in syzygies. The general result of the sun's disturbing influence is thus seen to diminish slightly the earth's power over the moon, and therefore cause the moon to revolve in a larger and larger orbit.

Another disturbing action on the moon is the changeable nature of the orbit in which the earth revolves. This caused great perplexity to La Place and La Grange; but they afterwards attributed it to a change in the eccentricity of the earth's orbit. However, Adams, of England, showed that the change of the earth's eccentricity was not enough to account for the moon's secular acceleration; and found another cause in the friction of the water on the earth's surface, as it revolves, thus tending to retard its motion, and lengthen the day. The present theory of acceleration is that the moon is really accelerated in her orbit about six seconds a century; and that the motion of the earth on its axis is little by little diminishing, amounting in a century to from two to six seconds. Olmstead gives the moon's acceleration as amounting to ten seconds in a century. It is supposed that if these changes were to go on for long, the solar system would fall into confusion and ruin; but La Place and La Grange proved, it is thought, that these irregularities can go on only for a time, when they will begin to rectify themselves. It may, however, be doubted, whatever their demonstration may have been, that the solar system, or any other system in the heavens, is stamped with eternal life. In our judgment whatever has had in time a beginning, will in like manner taste in time what is known as death.

The moon's path around the sun is in an epicycle; and although she goes around the earth, she always keeps the concave side of her orbital curve turned toward the sun. While the moon describes the inner half of her orbit around the earth, the latter passes over one-twenty-fifth of its annual path around the sun. Now if a line be drawn from the point in space occupied by the earth at the commencement of this semi-lunation to the point in space occupied by the earth at the end of this semi-lunation, it will be found that the moon's path has never been so near to the sun as the earth's path has been; and this means that the concave path of the moon's orbit related to the sun has always remained turned toward the centre of our system.

The action of the moon on the waters of the earth is generally well known. Both the sun and moon exert a similar influence; but the action of the latter is about ten-fourths of the former. Near the times of new and full moon both sun and moon are in position to have the greatest combined effect in producing tides; and when the two bodies are 90° apart, they act in different directions, the sun tending to produce high-tide, and the moon a low one. Near the times of new and full moons we therefore have spring-tides; and near the quadratures we have what are called neap-tides. There are many modifying quantities that have their influence on the tides; and these make a thorough knowledge of them not an easy problem.

The moon not only reflects the sun's light, but also radiates some of the heat it receives from the sun. It has been found that 86 per cent of heat received from the sun will pass through glass, but only 12 per cent of that received from the moon will pass through it. By the experiments of Lord Ross it is believed that six-sevenths of the heat received from the moon is radiated, and one-seventh reflected.

We all know that the sun is very much brighter than the moon; and it is not without pleasure that we frequently gaze on her beautiful face as she glides so gracefully along over our heads, but who of us can thus gaze into the face of the sun? Nevertheless we should scarcely think that the disparity is so great as it really is. Zöllner has found by quite exact experiments that the light of the sun is to that of the moon as 619,000 is to 1.

Our earth is a bright moon to the moon, reflecting upon her more than thirteen times as much light as she reflects upon us. So intense is the light received by the moon from the earth, that it is in a measure reflected back to us; and this is the explanation of the grey ashen color we sometimes see on the moon, beyond the part that is really lighted.

The real size of bodies are proportional to their apparent sizes. Therefore the earth as viewed by an inhabitant of the moon appears with a disk as much larger than that which the moon presents us, as 15 is to 4. To beings living on the side of the moon turned from us, the earth is never visible; but to inhabitants living on the hemisphere turned toward us, the earth would pass through phases very similar to the moon's phases as seen by us.

Since the earth revolves on her axis, a person on the moon must see every part of the earth once every twenty-four hours; but the very dense atmosphere surrounding our globe would probably be a great obstruction to thorough observation of the earth by inhabitants of the moon.

The full moon which occurs at or near September 22nd is called the harvest moon. At this time the interval from rising to rising is less than at any other time of the season. This is because the moon is near the vernal equinox, and the most southern part of the ecliptic is then above our horizon, making the smallest possible angle with it. In the higher altitudes the harvest moon is especially attractive; for the angle made by the ecliptic with the horizon becoming smaller as we go north, the moon is longer above us from rising to setting.

TABLE

Diameter 2163 miles;
Volume .020, Earth being unity;
Mass 1/81, " " " ;
Density .61, " " " ;
Gravity at surface 1/6, that of Earth being unity;
Synodic period 29d 12h 44m 2.7s;
Sidereal revolution 27d 7h 43m 11.5s;
Axial rotation synchronous with its sidereal period.

CHAPTER X

HISTORICAL SURVEY

IT IS impossible for a thinking mind to look at the heavens without wondering what are the bounds of Nature's kingdom, the limit of the stellar systems, and the form and structure of the visible universe.

Man's philosophical nature is proved by many an infant expression. We all have sung in days gone by when our hearts were full of childish glee, and our minds of wonder and expectation, as we gazed at the vaulted blue above us, and saw the stars come out one by one, "Twinkle, twinkle, little star; how I wonder what you are." As we grow older this wondering part of our nature loses none of its early power to engage both mind and heart in trying to fathom the mysteries around us, and more especially those of the awe-creating heavens above us. The lifting up of whole mountain regions by subterranean forces, and the bursting forth of volcanic fires, giving vent to seas of burning lava covering hundreds of square miles of surface, and spreading death and destruction everywhere in its course, are enough to strike the soul with terror at the thought of Nature's forces; but the profound silence of those mighty shining worlds, standing forever seemingly motionless, watching as it were the rise and fall of empires, and unmoved either at the death or birth of a world, is still more awe-inspiring and wonderful. So great has been humanity's longing, and so laborious its efforts to fathom the depths, and determine the nature of the visible universe that we can use the words of Aeneas in reference to man's astronomical efforts, with much more truth than Aeneas used them in reference to himself and people:

"Quis jam locus, Achate,
Quae regio in terris nostri non plena laboris?"
(Aeneid I. 458.)

Nor can we fail to believe that if the ardent soul of Copernicus could have seen arising, as Aeneas saw the walls of unhappy Dido's city, our present astronomical structure or scientific knowledge, he too would have cried out:

"O fortunati, quorum jam moenia surgunt." (Ibi 436.)

And when we think of the character of very many of the great souls who in ancient times as well as in more modern, have passed so many silent nights studying the silent heavens, trying to interpret the celestial signs, and tell the world the constitution and meaning of those speechless stellar wonders standing apparently motionless in the profundity of space, we can hardly help believing that they must have frequently used the words of father Anchises:

"Jupiter omnipotens, precibus si flecteris illis,
Aspice nos; hoc tantum; et si pietate meremur
Da deinde auxilium, pater atque haec omnia firma."
(Vergil: Aneid II. 688.)

Among the earliest investigators of heavenly phenomena Pythagoras occupies an eminent position; and it is probable that he taught the revolution of the earth around the sun — that the sun and not the earth is the real centre of motion. Of this Aristotle speaks in his De Coelo. (B. 13, 1.) But this doctrine was rejected by Ptolemy, who labored as an astronomer at Alexandria in the middle of the second century. This astronomer taught that the earth was the real centre of motion; and that it was kept in position by the mutual attraction and repulsion of the stars and planets which revolve around it. Speaking of certain ones who dissented from this doctrine, and who held that it was sufficient to suppose a revolution of the earth on its axis every twenty-four hours, in order fully to explain all the phenomena of the solar system, he replied that such a supposition would be wholly unscientific and unwarranted; that the fact we had an atmosphere was enough to refute any such teaching, as such a motion of the earth, he said, would necessarily cause the atmosphere to be left behind.

Ptolemy very ingeniously explained the movements of the heavenly bodies by what is known as his system of cycles and epicycles. According to this astronomer the heavenly bodies, then known, revolved around the earth in the following order: Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn. Beyond the circles of these globes lay the regions of the fixed stars, which then were conceived, and with no little reason, to be as it were a trackless desert, where the foot of mortal never trod nor could tread, and the mind of man never could penetrate — an abyss of space filled with mighty worlds, which moved as the cadent footsteps of the gods, or marked off in æons the time which Nature spins out of the loom of eternity. Ptolemy knew that the earth is a sphere, and that compared to many other heavenly bodies it is small indeed; but he rejected the true theory of the solar system held by others without any reasonable doubt, and maintained his views with much show of logic, and greater mastery of obscurity in his scientific reasoning.

The honor of discovering the true motions of the celestial bodies is by astronomers in general given to Copernicus; but I can not think that this is justly done. Copernicus was an ecclesiastic, and he was probably not unacquainted with what the ancients had said and written on the subject of celestial motion. I have said that the wisest of all ages have been led to investigate the celestial phenomena; but it is impossible to say on what man or nation the honor of making the first astronomical observation should be conferred. The Chaldeans, Indians, Egyptians, and Chinese have each had their advocates; but the question must remain undecided. It is said that on the capture of the city of Babylon, 331 B. C., by Alexander, Callisthenes, the philosopher who accompanied the king, collected Chaldean astronomical observations extending back 1903 years B. C., which he, at the king's command, sent to Aristotle. It is certain that the Chaldeans accurately observed lunar eclipses at yeast 720 years B. C.; they also understood the cause of solar eclipses.

The Egyptians determined the length of the year from watching the star Sirius emerge from the rays of the sun, and set it at 365¼ days. It is believed that they observed solar and lunar eclipses, and determined their causes; and they were acquainted with the true form of the earth, and with the revolutions of Mercury and Venus around the sun.

Astronomy is said to have been studied by the Chinese nearly 3000 years B. C., one astronomer receiving the crown of the country for his discoveries. The metonic cycle of 19 years was known to them; they knew of the north pole, and they made directions for the calculation of eclipses, and a catalogue of 2500 stars.

The Indians profess to have made astronomical observations as early as 753 years before the so-called flood of Noah, when the Old-Testament Adam was only 28 years old; and many eminent scholars, such as Bailly of France, Playfair of Scotland, and others, regard their claims as well sustained.

The Grecians were indebted for not a little of their astronomical knowledge to the nations which flourished before them, such as the Egyptians, and Phoenicians, and are supposed to have been more or less interested in astronomical observations for 13 or 14 centuries B. C. For 200 years after the middle of the 7th century B. C., it is certain that many illustrious men flourished in Greece, whose vast intellects were more or less attracted by the study of astronomy. Some of these travelled extensively, and gaining much information returned to their native land, and established flourishing schools of astronomy. Of such philosophers Thales, who flourished about the middle of the 7th century B. C., founded the Ionian school; and Pythágoras, returning from extensive journeys, and meeting with a cool reception from his own country, went to Italy where he founded, about the middle of the 6th century B. C., the celebrated Crotona school of philosophy. Following these two great masters were many able disciples, among the most celebrated of whom were Anaxmander, Anaximenes, Anaxagoras, Philolaus, Meton, and Democritus.

Thales taught that the moon borrowed her light from the sun; that lunar eclipses resulted from the moon's immersion in the earth's shadow, that the earth was round, and he divided it into five zones; that the equinoctial line was cut obliquely by the ecliptic, and perpendicularly by the meridian; and be foretold a solar eclipse.

Anaximánder, the immediate successor of Thales, taught that the earth was not really connected with the planets, and that the latter were inhabited just as is the earth; that the fixed stars were the centres of other planetary systems; that the sun was a glowing mass; and that the earth moved around the centre of the system.

Anaxágoras (natus B. C. 500), a most notable philosopher of the school of Thales, foretold lunar eclipses, and maintained that the moon was inhabited like the earth having like the latter hills and valleys and water. He was also a profound monotheist. So strong was he in his opinions that he offended the clergy of his day, and came within a hair's breadth of paying for it with his life.

Pythágoras (582 B. C.), the founder of the Crotonan school, in Italy, taught that the earth was a sphere, that it revolved on its own axis once every twenty-four hours, and around the sun once every year; that the planet Venus is both morning and evening star; that the milky whiteness of the milky-way is caused by an infinite number of stars situated at such great distances from us that they appear as points close together. In addition to these solid scientific truths he taught the existence of 12 spheres, those of the stars, Saturn, Jupiter, Mars, Mercury, Venus, Sun, Moon, fire, air, earth, and water, and that the spheres in which the planets were fixed, emitted sounds during the planetary revolutions, called the music of the spheres.

Philoláus taught these doctrines much more boldly than his master, and committed to writing what Pythágoras had taught orally only, fully expounding the master's views. It is from the writings of Philoláus that Plato is said to have extracted most of the matter in his Timaéus. The boldness of Philoláus led to such persecution on the part of the priests, that he was obliged to flee the country. After the flight of this astronomer the science of astronomy began to decline, and did not again regain its ancient prestige until about 300 years before the Christian era, when the well known school at Alexandria was established under the Ptolemies of Egypt.

On the death of Alexander the Great, and the division of his mighty empire, the government of Egypt fell to the lot of Ptolemy Stoer, who reigned from 323 to 285 B. C. This Ptolemy was the son of Arsinōe, a concubine of Philip of Macedon, and it is probable therefore that he was closely related to Alexander. It is certain enough that he enjoyed the friendship of Alexander long before the death of Philip, and that he accompanied that monarch in most of his campaigns. Ptolemy Soter originated the most splendid literary and scientific institutions at Alexandria, which under his successor, has youngest son, the child of his latest and most beloved wife, Berenīce, became universally famous. To the elder Ptolemy belongs the glory of founding the library and museum at Alexandria. In his literary and scientific efforts, he was undoubtedly largely governed by the eminent philosophers Stilpo of Megára, Theodorus of Cyréne, and Diodorus, surnamed Cronus. He also tried to have at his court Menánder and Theophrástus, but failed in his efforts. Under Ptolemy Philadelphus who reigned from 285 to 247 B. C. and who was the son of Soter by his wife Berenice, the museum at Alexandria became the resort and abode of all the most distinguished men of the day, and in the library were accumulated all the treasures of ancient learning that could be collected.

At the school of Alexandria, Aristárchus, of Samos, flourished between 280 and 264 B. C. This astronomer adopted the views of Pythágoras in regard to the earth's motion around the sun; and he held that since the stars appeared to keep the same fixed position in space, when viewed from opposite points of the earth's orbit around the sun, their distances must be vastly greater than that of the sun. He also discovered a celebrated method for determining the relative distances of the sun and moon. He came to the conclusion that when the moon was just exactly half illuminated by the sun, and an observer on the earth saw, therefore, exactly one-half her disk covered, a line drawn from the sun to the moon would be perpendicular to one drawn from the moon to the earth, the two lines therefore subtending a right angle; and that since he could measure the angle formed by the lines drawn from the sun to the earth and the earth to the moon, all the necessary elements of the triangle were present to form a proportion, the signs of the angles being proportionate to their opposite sides. This principle is correct enough, but it is very impracticable because of the very great difficulty any one must find in knowing just when exactly one-half of the moon is illuminated. He found by measurement that the angle was 87°. This error was caused not by his ignorance, but by the imperfection of his instruments. The true greatness of the scholar consists not in his being able to apply unerringly the carpenter's rule, or measure correctly the number of degrees two lines subtend; but rather in his discovery and application of principles. A skilful physician may be necessary to diagnose the disease; but any one can give the medicine directed to be given.

Another great astronomer of the Alexandrian school was Eratosthenes, a Grecian philosopher, born at Syrene, B. C. 276. So celebrated was this philosopher that he was invited to the court of Ptolemy Euregetes, and appointed royal librarian. He determined the obliquity of the ecliptic or the difference between the sun's position in the heavens at the equinox and at the solstice, and set it as 23° 51′ 20″, which is just about correct. He also was the author of a correct method of determining the circumference of the earth, although his lack of scientific instruments led him to false results.

Conon of Samos, Archimides the great geometrician, and Apollonius of Perga, were all eminent astronomers. The last is believed to have been the real author of the cycles and epicycles of Ptolemy.

The Newton of ancient astronomers was Hippárchus son of Pisitratus, who was born at Nicaea, in Bithynia, and flourished from B. C. 160 to B. C. 145. He raised the science of astronomy to a higher rank than it had ever before known, and discovered methods for solving all triangles rectilinear and spherical. He verified the obliquity of the ecliptic as given by Eratosthenes, fixed the latitude of Alexandria, and found within six minutes the exact length of the year. He was led to observe that the sun is nine days longer in passing from the vernal to the autumnal equinox, than from the autumnal to the vernal; and two days longer in passing from the vernal equinox to the summer solstice than from the summer solstice to the autumnal equinox. Hippárchus, as did all astronomers down to the days of Kepler, kept to the old doctrine that the heavenly bodies moved in circular orbits, and with uniform motion. In accounting for the variations in the rate of the motions of the heavenly bodies, he taught that the earth was situated some distance from the true center of motion. He formed a catalogue of the fixed stars; he was the real author of the planisphere, having mapped out the heavens on a plane surface; and he transferred this map-method to his geographical determinations of latitude and longitude. Having noticed that the star chosen 170 years before by his predecessors to mark the equinoctial period, failed any longer to do so; he came to the true conclusion that the sun's position in the heavens is not unchangeable, that in fact it moves slowly westward among the stars. Thus he became the discoverer of the precession of the equinoxes, although it is improbable that he ever understood the cause of this phenomenon which Sir Isaac Newton discovered to be owing to the protuberance of matter about the earth's equator.

After Hippárchus the celebrated Ptolemy appeared, who flourished about the middle of the second century before the Christian era. Ptolemy was a great practical astronomer, the best geographer of antiquity, a chronologist, a musician, and optician. He left behind him a celebrated work on astronomy called the Almagest, (an Arabic word meaning the great Composition), a work based on the labors of Hippárchus, but which remained the authority in all astronomical questions for more than fourteen hundred years. The astronomical sceptre of this work was no less powerful that the sceptre swayed by Galen in physic or that swayed by Aristotle in philosophy. It was divided into thirteen books. In this system the earth and not the sun is made the centre of motion; and the variations in the rate of the movements of the heavenly bodies, are explained on the theory that the earth is some distance from the true centre of motion: this is called its eccentricity. The system of Ptolemy satisfactorily accounted for all the heavenly phenomena.

After the death of Ptolemy the star of astronomy began to set. The fall of the Roman empire; the introduction of new religions, and the shaking up of the people's faith in any and all; the inroad of barbarianism, and the accumulation of all power in the hands of the ecclesiastics of the new faith, resulted almost in the total destruction of all art and science, of literary pride and scientific ambition. Not until the 9th century was anything like science born again in the world; and then this beautiful child appeared as a messenger from heaven not among the arrogant ecclesiastics, who claimed all power in heaven and earth, but among the infidels who marched under the banner of Mahomet. Almamon, an Arabian prince, invited, at this time, all the more celebrated scholars of his day to his capital, Bagdad. He obtained very many Greek MSS. which had been deposited at Constantinople, the Almagest of Ptolemy being among the number; and of this latter work he had made an Arabic translation, thus bringing to the light of day the astronomical knowledge which had lain in ruins caused by the ravages of war and the fall of empires.

The greatest of all the Arabic astronomers was Albatégnius, governor of Syria. The Arabians made but little addition to the astronomical knowledge already acquired; but it is to their lasting glory that wherever their power extended, there they sought to implant a love of the arts and sciences among which was astronomy; and it is to them that Europe is indebted not only for the revival of astronomical studies, but for the knowledge of much else which to-day enters into the framework of the scientific temple.

Astronomy was cultivated by the Persians from the 11th to the 15th century; and Ulugh-Beigh, a Tartar prince and grandson of Tamarlane the Great, rose to quite an eminent position in the science, having made a new catalogue of the fixed stars, and framed accurate astronomical tables.

The Arabian seed took deep root in Europe. Alphonso X, king of Castile, was the first of European sovereigns to take under their protection the science of astronomy. Near the middle of the 13th century, he built a school at Toledo to which all the Arabic scholars in Spain were pressingly invited. By these scholars the celebrated Alphonsine tables were drawn up, and published in 1252. From Spain the love of astronomical studies spread into other parts of Europe.

At this time the doctrine of the immobility of the earth, and that of the circular and regular movements of the heavenly bodies around it, were universally held as unquestionable truths; and if any one should be led to think differently, he soon became too conscious of the danger of expressing his thoughts, lest the ecclesiastics should cut his tongue out for his indiscretion, excommunicate him, and consign his soul to the everlasting companionship of the devil and his angels. Lactantius who because of his so-called "varied erudition, sweetness of expression, and grace and elegance of style," has always been one of the most esteemed of the Christian fathers, and who flourished near to the middle of the 4th century, could hold up to ridicule, in the 23rd and 24th chapters of his Divine Institutes, those who teach that the moon may be inhabited, call lunatics those who say that the earth may be a moon to the moon, senseless those who believe in the existence of the antipodes, and declare as guilty of wilful falsehood those who teach that the earth is round like a ball. According to this Christian father any one with a very little divine wisdom can easily combat all these foolish errors. Aristotle had unquestionably taught the immobility of the earth. (De Coelo B. 14, 5.)

About the middle of the 15th century an obscure Roman priest, called Nicholas de Cusa, stated his belief that the earth was not stationary but revolved, and that the sun was fixed as the centre of movement.

Bernard Walther, of Nuremburg, was an astronomer of no mean distinction. He described the orbit of the comet of April, 1500, translated Ptolemy's geography, explained the present method of finding longitude at sea by knowing the distance of a fixed star from the moon, and determined the amount of the precession of the equinox as being 1° 10′ in every 100 years.

The celebrated Leonardo de Vinci, chiefly known as an Italian painter, flourished about this time. He was wonderfully accomplished in all the known arts and sciences. Hallem tells us that the theories which afterwards made famous such characters as Galileo, Kepler, Maestlin, Mausólicus, Castelli and others, were all anticipated by this genius, as if by preternatural knowledge. He accepted the theory of Nicholas de Cusa as to the mobility of the earth; and in 1510 he connects the fall of bodies with the earth's motion as a thing generally received.

Copérnicus, born at Thorn, Prussia, in 1473, studied astronomy under Domenico Maria of Ferrara, mathematical professor at Bologna; and there is reason to believe, says Sir David Brewster, that Maria's hypothesis of the variability of the axis of the globe, suggested to Copernicus the idea of explaining the celestial phenomena by the motion of the earth. About the year 1500, Copérnicus went from Bologna to Rome, having accepted there the chair of mathematics. It was while acting here as professor that he adopted the theory of the revolution of the earth and all the planets around the sun as the centre of planetary motion; and in coming to this conclusion, he says he was influenced by what he had heard and seen of the teachings of Pythagoras and other ancient philosophers, and more especially by the writings of Capella, a Roman writer of the 5th century. In 1510 Copernicus left Rome for his native country, where he was presented, through the influence of his uncle, with a canonry at Frauenberg. Although Copérnicus believed that the sun was the true centre of motion, he still held to the old teachings that the celestial bodies moved in circular orbits and with regularity of motion; and he was therefore forced to adopt the eccentric and epicycle of the Ptolemaic system. Copernicus fully believed that the doctrine of the immobility of the earth was an error; but he was led for many reasons to hesitate making very public his views, being afraid of ecclesiastical degradation and punishment; for well he knew that the Ptolemaic system was everywhere received by the church. Already the cry "infidel" was heard in the air; already had he been caricatured on the Elburg stage; and it is not at all likely he would ever have consented to the publication of his views, had he not been urgently pressed to do so by an intimate and rather powerful friend. Even as it was, he delayed so long that he never saw a printed copy of his work, a proof of it having been just brought him a few hours before his death, which occurred May 23rd, 1543.

Many astronomers followed Copérnicus, but none of great note arose before the appearance in our earthly horizon of that star of the first magnitude, Tycho Brahe.

Tycho Brahe was born at Knudsthorp in Denmark, December, 1546. Born of noble parentage, and having many advantages, social as well as scientific, and having more than ordinary ability, he was sure to excel; for with such advantages success is almost certain. While prosecuting his studies at the university of Copenhágen, his mind was turned to the study of astronomy from observing an eclipse of the sun, August 21st, 1560, which he saw was the very time that had been predicted by the astronomers for its occurrence. He became assiduous in the study of celestial phenomena, and spent much money in purchasing instruments to enable him better to prosecute his labors. Having spent much time at his favorite study, and becoming acquainted with most of the celebrated astronomers of his day, he erected, by the aid of his uncle

Steno, a laboratory and an observatory. It was at this observatory that he discovered, November 11th, 1572, a new star in the constellation Cassiopeia, larger and brighter than Venus, and which was visible more than a year, but growing less and less brilliant, finally disappeared in March, 1574. It was through the strong influence of William, Landgrave of Hesse, that Tycho was brought to the notice of Frederick II of Denmark, by whom he was presented with the island of Huena for life. He was now in quiet and easy circumstances, having a salary of 2000 dollars a year, a canonry in the church, and the income of a fief in Norway. Surely no one could wish for better conditions! It was here on this Baltic-sea island that Tycho erected his Uraniborg, and continued pursuing his favorite study for the period of twenty-one years, all the time enjoying royal favor. Far and wide spread his fame, and many were the distinguished persons that came to see him, among whom was no less a personage than King James I of England, who spent a week with him on his island retreat. His glory was enough to excite jealousy in the hearts of those less fortunate. The medical fraternity were angry at him for giving gratuitous services to the poor, and the nobles were incensed at the many royal favors showered upon him. Finally, Wilchendrop, minister of the crown, having succeeded in poisoning the royal heart, Tycho was deprived of all his emoluments, and obliged, in 1596, to bid adieu to his native land. Like a bird robbed of its nest, he looked for some time for a place where himself and family could settle down; but found none until he was invited by Emperor Rudolph II of Bohemia to settle at Prague. Here he became royal mathematician at a salary of 3000 ducats a year. But many as were the favors he received from this emperor, and high as was the position he filled, yet his heart was in his native land; and he pined away like a captive bird, dying of something like a broken heart, October 24th, 1601. It was perhaps fortunate for the world that he went to Prague; for it was here that he met the immortal Kepler who under his teachings was led closely to observe celestial phenomena, and from such observation to deduce sound philosophical conclusions.

The system of Tycho Brahe was a mixture of the Ptolemaic and the Copernican. He held that the earth was the true centre of motion, and that the sun, the five planets revolving around him, described an annual orbit around the earth. Tycho swept aside the doctrine of the crystaline spheres, made a catalogue of 777 fixed stars, made improvements in the lunar theory, gave us a better knowledge of astronomical refraction, and left us a vast mass of accurate astronomical observations by the aid of which Kepler, his pupil and successor, was enabled to immortalize himself.

The age that was illuminated by the light of a Kepler, was also illuminated by the light of a Galiléo; and these two men were scattering the darkness to enable the penetrating eye of a Newton to sound the depths of the universe.

Galiléo was born in 1564, at Pisa, Tuscany. He first studied medicine, but relinquished that study for the more agreeable one of mathematics, in which he soon became so proficient that he was appointed mathematical professor in his own native-town university. Soon he began to call in question many of the theories widely received, and to treat rather disrespectfully those who gave them credence. Thus stirring up around himself a multitude of enemies public and private, he was obliged to quit Pisa, and go to Pádua, where he filled the chair of mathematics. Here he remained for eighteen years urging forward the studies of mechanics and optics, and finally discovered the law of gravity as manifested on the earth's surface, the uniformily accelerated motion with which bodies fall to the earth, and the rate of that acceleration.

Learning while on a visit to Venice that a person by the name of Lippersheim, a Dutchman, had made some kind of an instrument by which distant bodies were made to appear as if they were near, he went to work on his return to make such an instrument himself. He finally succeeded in making a telescope that magnified a thousand times, or that brought the heavenly bodies thirty times nearer than when seen by the naked eye. With this he began to examine the heavens above him. How his soul must have been enraptured when for the first time he gazed through his telescope on those distant worlds! It was not long however that he was to enjoy such blissful feelings; for the ecclesiastics are on his path as bloodhounds after the slave. In 1615 he was denounced before the court of the Inquisition, where his doctrines of the mobility of the earth and the stability of the sun, were declared to be expressly contrary to Holy Scripture, and erroneous in faith. In 1633 he was forced by the same Inquisition to recant, and publicly curse his own teachings, and sentenced to confinement, in the prison of the Inquisition, during the pleasure of the pope. He was kept more or less under surveillance during the rest of his life; but it is said by some that for a few days before his death he was set at liberty. He died January 8th, 1642; and the ecclesiastics refused his friends permission to raise a headstone over his grave. Nature seemed so greatly offended, that the same year Galiléo was sent out of the world, she sent a greater one into it, the world-renowned and never-to-be-forgotten Sir Isaac Newton.

Our historical survey has brought us to the days of Kepler and Newton who standing upon the structure erected by the master minds of the past, searched so thoroughly the depths of the heavens, and opened so widely the doors that admit the soul of man into the deep mysteries of nature, that the modern world is all ablaze with scientific light, and the astronomer is surrounded with a halo of glory. With the lives and works of these two immortals, it is incumbent on every one to make himself acquainted; and surely such an acquaintance is not difficult in an age of printing and scientific dissemination.

As you pass over the domain of science, you will everywhere find footprints of the ancients; and as Huxley says, "It may be asked if even-handed justice has ever yet been dealt out to the sages of antiquity, who for eight centuries, from the time of Thales to that of Galen, toiled at the foundations of physical science." (Reign of Queen Vic., II. 323.)

CHAPTER XI

ATOMIC AND MOLECULAR WORLDS

FROM the earliest ages the subject of cosmology has attracted the profoundest minds. The nature of the mind is such that the thoughtful soul can not rest in the presence of a mystery without attempting its solution; and no mystery is so great as that of the origin and constitution of existence. In proof of how greatly the races of mankind have interested themselves in this question, nothing more conclusive needs be produced than the fact that they all have made their own cosmogonies, from the heathen worshiping a god most grossly anthropomorphic in character, to the Hindu adoring the universal abstraction, Brahm. Nor is it at all strange that such interest should be manifested in trying to answer the question, whence is being, what are the laws which govern it, and what its end. If in the still hour of night when our thoughts are solemnized by the apparent death of the mad world around us, we are troubled with the questions of our own origin and end, how natural is it that the human mind should seek to know something of the origin of the cosmos as a whole, the laws with which it moves in cosmic order, and the future of the awful fabric. It is certain that man derived so completely from nature as he is, must in the contemplation of this subject greatly increase his love of nature, the sense of his unity with it, and the consciousness of how great and awful must be that Universal Whole; and it must also increase his powers of sight and hearing, enabling him to see beauty in forms which hitherto have refused to reveal their character, and to hear harmonies which only the soul tuned to nature's music can ever hear. He that feels most his oneness with nature, is surely within the kingdom of God, and best able to hear and interpret that mysterious voice whether walking in the garden in the cool of the day, or seeking repose in the dead hour of night. This subject therefore is most of all calculated to make us lovers of nature whose offspring we are, and more able and willing to obey her laws, whether it be to live or to die.

Since the universe is one, it is evident that force can neither be added to it nor taken from it. It is the Universe, the Whole; and by this we mean that whatever is or is conceived to be, whatever has been or is conceived to have been, whatever shall be or may be conceived to be, is of it and in it, and can not become out of it nor lost to it. Since the universe is one, the sum total of energy is invariable: it remains the same to-day as it was yesterday, and as it shall be forever. The powers of being may manifest themselves in countless forms, but the totality of the forces making up the whole can neither be diminished nor increased. Hence the reasonableness of the now universally received doctrine of the Conservation of Energy. The matter so-called which constitutes our bodies at the present time, was as old as eternity, when it first became a constituent part of that fiery mist or nebulous chaotic mass which was destined in time to become the mother of our solar system; and age shall not have affected it, even after this system shall have been buried in oblivion. But after the burial of this system, we would not have you think that there shall not be a resurrection. As with that speck of nature we call man, so with every larger part: to each there is a birth-time, an infant state, a childhood, youth, maturity, middle-life, old age and death; and as the different forms of life continue their kind at the expense of their own life, so with the larger portions of the awful cosmos: by their death they insure a better life, and in their burial they have a reasonable hope of a glorious resurrection.

But whereas with man his days are as if a shadow, or something that is not, with these greater parts of the whole there is almost an endless life, they continuing thousands of millions of years in a state of infancy and youth, countless ages in a state of maturity, and as long finding their way in their old age to the grave. Who can withhold his admiration at beholding the mighty Jupiter with a volume at least 133 times that of our earth, and a diameter of 87,000 miles, sweeping through the courts of heaven, attended by all his princely followers? or at the not much less majestic and yet more wonderful Saturn attended by his ten royal personages, and having, as it were within speaking distance, myriads of lesser attendants all resplendent with glory, and perfectly obedient to his will? It is scarcely to be wondered at that millions of our fellowmen, unblessed with the revelations of modern science, should worship such wonders of nature as divine beings; but to those on whom the light of science shines, they appear with all their magnificence but children of nature, the common mother, born to keep their identity not forever but for time only; while the Force by which they were, are, and cease to be, continues unmoved, and unaltered, notwithstanding the birth and death of a million million worlds. The true child of nature thus learns to feel his oneness with the whole, and to sympathize with all its varied parts in their health, their sickness, and their death. The budding tree recalls the mind of such to the scenes of his childhood; while the falling leaf, or the decaying trunk but prophesies that he too, ere long, must in like manner return to the mother that gave him life. Surely it was such thoughts as these that led Goethe to represent the earth-spirit as saying:

"In the currents of life, in the tempests of motion,
In the fervor of art, in the fire, in the storm,
Hither and thither, over and under, wend I and wander.
At the whirling loom of time unawed,
I work the living mantle of God."

As the contemplation of the origin, order, unity, and meaning of the cosmos, has engaged the powers, and called forth the admiration, of the greatest and best of all ages; so to-day whether we study the infinitely great or the infinitely little, the hundred million stars, resplendent beings, appearing in our telescopes dimly out of abyssmal obscurity, or the atomic worlds moving in their orbits with a velocity comparable to that of Jupiter moving in his, and forming systems not less wonderful than the stellar, though inconceivably small, — we everywhere behold the works of unity and beauty, the works of law and order, and everywhere find indubitable proof that all are parts of the stupendous whole, of one Divine Body.

In the study of the stars, suns, and planets we find wonderful existences all bound together by sympathetic bonds, actuated by one general impulse, and acting under one general law, and producing a harmony incomparably greater than that seen in man as the result of the united organic forces which constitute his being. So in the study of atoms and molecules, we shall find nothing less wonderful nor less worthy of our admiration, than in the study of the greater worlds.

Though the distance from one side of the stellar system to the other is so great that light passing at the rate of 186,000 miles a second takes about fourteen thousand years to cross it; yet it is probable that the stellar system is no larger when compared to our sun, than is a molecule of alcohol, when compared to one of the atoms composing it. As carbon, for instance, is but one atom of the molecular system forming alcohol, so is the sun but an atom, when compared to the stellar system of which he is a part. It may be safely said that to the philosophically minded, and more especially to him who in addition to such philosophical mindedness has the poet's imagination, the infinite smallness of nature is no less wonderful than is its infinite vastness. If it takes 14,000 years for light to cross the galaxy, it probably takes it relatively no less to pass from side to side of a molecule of alcohol. Ehrenberg who investigated the subject of infusoria very extensively, estimates the possible number of these organisms in one drop of water as not less than five hundred millions. As it is not probable that any one of these animalcules contains less than ten thousand atoms, it would follow that in a drop of water there might be 500,000,000,000 atoms forming the animalcules that live in it, in addition to the countless millions of atoms forming the water itself. Sir William Thompson estimates that in transparent bodies it may require 5,000,000,000 atoms to extend one inch; and Gaudin calculates the number of atoms forming a pin's head as likely not less than 8,000,000,000,000,000,000,000, eight sextillions. If such a number could be counted at the rate of a million a second, it would take two hundred million years to complete the count. Nor should you imagine that science is here only vainly babbling, when giving utterance concerning such matters; for she is certainly acting within her legitimate sphere, and with reasonable assurance.

With the highest known magnifying power we can distinguish the forty-thousandth part of a centimetre. "Now," says Sir Henry Roscoe, "if we imagine a cubic box each of whose sides has the above length, such a box when filled with air, would contain from sixty to one hundred million atoms of oxygen and nitrogen. Or to put it in another form, — if we supposed that the minutest organisms were provided with equally powerful microscopes, these beings would be able to see the atoms." And Sir William Thompson tells us that were we to imagine a drop of water magnified up to the size of the earth, then the coarseness of the grains would be somewhere between small shot and cricket-balls. This eminent physicist has given us reason for believing that the number of atoms in a solid or liquid cubic centimetre lies somewhere between three times the twenty-fourth power of 10 and the twenty-sixth power of 10; in the former case the number would be expressed by 3 followed by twenty-four ciphers, in the latter case by 1 followed by twenty-six ciphers. That is, the number of atoms in a cubic centimetre lies between three septillions and one hundred septillions. To understand how vast is the quantity expressed by a row of twenty-seven figures, we may say that it is not beyond the calculation of the human mind to express in this manner the number of atoms there must be in the vast stellar sphere, supposing it to be filled throughout with some kind of solid matter. It is true that this sphere is so large that it is almost inconceivable, yet such calculation will show us, notwithstanding its vastness, that it would not require a quantity greater than that represented by ninety-two places of figures to express the number of atoms such a sphere contains. The number of atoms in such a sphere will be expressed by about 68 multiplied by 10 raised to the ninetieth power. This gives us a faint impression of the power of figures; but although the calculation might be near enough, no finite intelligence could begin to comprehend fully such a quantity. It was shown long ago by Archimides, in a most remarkable work called the Liber de Arenae Numero, that it would be an easy matter to express by arithmetical notation the number of the grains of sand contained in the earth. Indeed, if all the globe were sand, the number contained in it would be as nothing compared to the number of atoms in the stellar sphere mentioned above. Supposing there are one hundred grains of sand to one inch in length, the whole number in the solid globe would be expressed by 66,318 followed by twenty-seven ciphers — in English numeration, sixty-six quintillions three hundred and eighteen thousand quadrillions.

While such considerations show in some respects the greatness of man, it can not fail for other reasons to impress upon him a deep sense of his utter inability to grasp the full meaning of any of the infinite variety of forces manifested by the boundless universe. However well developed our powers of vision may be, it still remains a fact that the colors invisible to us may be vastly more than those visible; and the sounds audible to us may be but few compared to the infinite gradations in the unlimited scale of Nature's music. Vibrations of more than 38,000 a second are inaudible to the average ear. But how infinite are the vibrations of nature! Indeed there is more reason than might be at first supposed for the belief of certain ancient scholars in a music of the spheres as they roll through the trackless regions of boundless space. For aught we know to the contrary, music sweeter than ever entered the heart of man to conceive, may be incessantly thrilling the infinite forces that throb throughout the universal Whole. Even the vibrating atom may be producing music compared to which the sweetest ever heard by mortal man, might be but irritating discord.

Dalton and Graham showed that the atoms of a gas are in constant motion, and that Joule accurately determined the rate of that motion. In a paper read at a meeting held in Swansea, in the year 1848, Joule said: "Thus it may be shown that the particles of hydrogen, at a barometrical pressure of thirty inches, at a temperature of sixty degrees, must move at a velocity of 6225.54 ft. per second, in order to produce a pressure of 14.714 lbs. to the square inch." Referring to this statement of Joule, Sir Henry Roscoe says, that "A molecular cannonade or hailstorm of particles at the above rate, a rate we must remember far exceeding that of a cannon ball, is maintained against the bounding surface." Clerk Maxwell, that able and lamented physicist, calculated the number of times a hydrogen molecule, moving, as we have seen, at the rate of seventy miles a minute, must strike against other molecules composing the hydrogen swarm, and found that in one second of time it must knock against others no less than 18,000,000,000 times.

Nor must it be supposed that even with such a vast number of atoms in a cubic centimetre as we have said, they are absolutely in juxtaposition, or that there are no spaces between them. The truth is that there are no two atoms absolutely close together. As there are spaces between the worlds that roll above us, so are there similar spaces between the many worlds that roll in a single molecule of alcohol, infinitely small as the sphere of their motion must be. Indeed, we may say that it is not at all probable that the space between two atoms is relatively less than that between two such suns as θ' Tauri and θ'' Tauri, found in the constellation Taurus, near Aldebaran.

Wherever we cast our eyes we find nothing at rest. Every body in the heavens moves under the impulse of several motions. The earth has its diurnal rotation on its axis, its yearly motion of translation around the sun, a revolution of the line of apsides accomplished in 112,691 years, another motion which is completed in about 25,868 years, and lastly a fifth with the solar system through space, accomplished in about 27,000,000 years. So with the atoms, none is at rest, none is in perfect contact with another; all are in a state of incessant vibration; and whatever material body we may see, and however much at rest it may appear, we may be sure that it is made up of a vast number of these whirling parts which never touch one another, and never come to a state of rest. Whatever motions are manifested by the heavenly bodies, may also be possessed by atoms. They may move around one another, revolve on their own axis, oscillate, or move subject to several of these motions at once. Indeed, to him who looks behind mere appearances, these little worlds seem to be full of life rather than the embodiment of death.

It is human for man to depreciate what he possesses in abundance; and it is not uncommon for us to treat slightingly what becomes subject to our will, even though to gain possession of it at first may have almost cost our life. The old proverb, familiarity breeds contempt, is to some extent the explanation why we think so little of those parts of nature with which we are most familiar, and with which, even though we feel no oneness now, ere long we must have our lasting companionship. It is humiliating in the extreme for one to bow the knee to him whom he has despised or treated with contempt; and it seems to me, that to him who has passed through this life with his eyes closed to the beauties of nature, and his ears deaf to her music, the thought of his future sepulchral abode, where he will have none for companions but those he has spurned with his feet, must be extremely disagreeable.

It is said the pure in heart see God. This saying is doubtless true. But he who has not eyes to see this God in the rippling brook, the sprouting seed, the budding tree, the suns that roll, or the hydrogen atoms, will look long ere he sees him elsewhere. I can not doubt that one of the surest stepping-stones to a higher life, is the learning to love the beauties of nature as she displays them in her infinite variety of ever changing forms. The true student of nature sees in her not the dead thing which the unthoughtful imagine. Indeed, he is conscious that almost every form of power manifested by the highest human intelligence, is in some degree manifested by the most loathesome animalcule that we destroy without a thought of the wonderful powers shut up in this microscopic organism. As with the organic atom, so with the inorganic, — to the soul schooled to appreciate nature's revelations, nothing seems to be dead, nothing seems to be common: indeed the heart and mind of such a person seem to be most influenced by the immanent Soul of the Universe, who has sanctified all his works by his eternal presence; and it is vain for human to treat with disdain what the Divine Being calls holy. A thorough study of atomic forces and laws will enable us better to appreciate and understand the thoughts of those great scholars who have entered into the secret dwelling-place of Nature, and beheld her in all her queenly beauty. The most pious souls that have ever lived to grace this earth, have been those who have most loved nature; and it is to them that Nature has most revealed herself. It would appear that a common spirit pervades the mighty fabric, and that through its power the very atoms vibrate with pleasure at communicating to the heart of the sympathizing investigator the secrets wrapt up in their breasts; and as they have never been contaminated their judgment is true, and their revelations not subject to correction. It was this feeling that made the great, and perhaps never-since-equalled Marcus Aurelius to say: "There is but one common matter, though it is parcelled out among different bodies. There is but one sensitive soul too, notwithstanding it is divided among innumerable natures, and individual limitations. And lastly the rational soul though it seems to be split into distinction, is but one and the same. . . . All are upheld by intelligent being. Our duty is to live easy and cheerful, and to crowd one good action so close to another that there may not be the least empty space between them." The great Faraday, a Christian, appears to have had a feeling similar to that which pervaded the breast of the above mentioned noble and pure Roman; for it was he who would be careful to remove his hat, when performing an experiment, as if the place was holy where Nature had chosen to remove her veil which ever conceals her from the gaze of the passing multitude and the eye of the vulgar. A knowledge of the wonders and perfection of Nature, and of man's perfect oneness with it, will most certainly strengthen one to adjust his actions to the natural order, and to be satisfied with her decisions; for that which fills the whole with life, and law, and order, sustains it in every peril, and guides it in every difficulty, and never for a moment forsakes any part of it, is surely able to decide well for us. Man should think of this universe as the City of God; then like Marcus Aurelius would he be able to say: "Hark, ye friends; you have been a burgher of this great city. What matter though you have lived in it five years or three; if you have observed the laws of the corporation, the length or the shortness of the time makes no difference. Where is the hardship then if nature that planted you here, orders your removal? You can not say you are sent off by a tyrant or unjust judge. No; you quit the stage as fairly as a player does that has his discharge from the master of the revels. 'But I have only gone through three acts, and not held out to the end of the fifth.' You say well; but in life three acts make the play entire. He that orders the opening of the first scene, now gives the sign for shutting up the last; you are neither accountable for one nor the other; therefore retire well satisfied, for He, by whom you are dismissed, is satisfied too."

CHAPTER XII

ATOMIC AND MOLECULAR WORLDS CONTINUED

EMPEDOCLES, 500 B. C., held that in the beginning all matter existed undifferentiated as one universal sphere; that all matter is really one; that all the various forms possible are but the result of mixture and change. Aristotle tells us in his Metaphysics that Leucippus and Democritus, 460 B. C., taught that matter is composed of atoms, which themselves are indivisible, and that between them is nothing but empty space. They taught also that the weight of each atom is proportional to their individual magnitude; that they are eternal, and have an original motion of themselves, of a vibratory character. Not a little of what we know therefore to-day was taught 2400 years ago; but modern science has penetrated into the holy of holies, as it were, of the atoms of the ancient philosophers; and every step it takes increases its profound reverence at the wonderful revelations. You remember that we have stated Gaudin estimates the number of atoms in a pin's head as about equal to the quantity expressed by 8 followed by twenty-one ciphers; so Loschmidt states that in a cubic millimetre of hydrogen there are not less than 15,625,000,000,000,000,000 — that is not less than 2,500,000 in a millimetre length. Where such vast numbers are found, reason could not suppose that exact and similar conclusions would be deduced by different physicists; but all such scholars come within certain declared boundaries in their determinations, and all their estimates are amazingly similar, considering the profound character of the subject.

It is generally said that Graham is the only one who ever dedicated his life to the study of the nature of atoms. It was he who discovered the law between the rate of motion and the density of a gas; for it was he who enunciated the principle that the relative rates of the diffusion of gases are inversely proportional to the square roots of their densities. The density of oxygen, for instance, is to that of hydrogen as 16 to 1; but its diffusibility is to that of hydrogen as 1 is to 4. Graham gave this law to the world in a paper which he read, December 19, 1831, before the Royal Society of Edinburg. Another fundamental law of chemistry was discovered by Robert Boyle: that the pressure of a gas is proportional to its density. Another simple law is that known as the law of Charles; which is that all gases, measured under constant pressure, expand equally for equal increments of heat. For instance, a volume of gas at zero becomes 1.3665 at 100°, thus making the coefficient of gas expansion about 1/273 for every degree Centigrade of increase in temperature. It is said that these three laws have been the means of giving us more knowledge concerning the real constitution of matter than all the preceding speculations of two thousand years.

Graham's idea of matter was, that fundamentally all matter is one. Throughout the vast system of nature, however many the elements may appear to be, according to Graham there is but one, all the existing so-called elements being but one and the same under different atomic or molecular conditions. "Let us imagine," he said, "one kind of substance only to exist — ponderable matter; and further that matter is divisible into ultimate atoms, uniform in size and weight: we shall have one substance and a common atom. With the atoms at rest, the uniformity of matter would be perfect. But the atom possesses always more or less motion, due, it must be assumed, to a primordial impulse. This motion gives rise to volume. The more rapid the movement, the greater the space occupied by the atom, somewhat as the orbit of a planet widens with the degree of projectile velocity. Matter is thus made to differ only in being lighter or denser matter. The specific motion of an atom being inalienable, light matter is no longer convertible into heavy matter. In short, matter of different densities forms different substances, inconvertible as they have been considered."

In 1863 Newlands investigated the subject of atomic relationship, and gave his conclusions to the scientific world. He found a most wonderful and far-reaching series of relationship among the atoms of many different so-called elements, especially in the Bromine, Chlorine, and Iodine series. England as in so many other great discoveries of modern days, so here had the honor of opening the way; but cool-headed Germany and imaginative Russia, the former in the person of her son Lothair Meyer, and the latter in the person of Mendeljeff, not only laid hold of the Englishmen's conclusions, but greatly extended their investigations along the same line. The chemists mentioned, among whom Carnelley must be reckoned, conclude that all the elements have a regular sequence, and show a periodic recurrence of analogous chemical and physical properties, and manifest an arrangement which they call the periodic system of the elements. To explain what is meant by this, Roscoe, an English physicist, says somewhat as follows: "Let us in our minds write on our mental blackboard the names of the Englishman Newlands, the Frenchman Dumas, the German Meyer, and the Russian Mendeljeff, all written in a horizontal line; next let us write beneath the name of each of these men the name of his father, and beneath that the name of his grandfather, and beneath that the name of his great-grandfather, and so on. If you now write opposite the name of each of these individuals the number of years since his birth, you will find the numbers will increase by a definite increment, namely the age of a generation, which will be approximately the same in all the families. There will be certain differences in the ages of the chemists themselves, but such differences will be little when compared to the period that will be found has elapsed since the birth of any of their ancestors. In these family-trees, each individual takes the place, as it were, of a chemical element: as each family is marked by certain peculiarities, so each group of atoms thus arranged show marked and unmistakable signs of a common origin. In such a family-tree as we have mentioned, it may frequently happen that the history of some member of the family has been entirely lost. When such is the case it is not impossible, especially for a man like Francis Galton, to judge from the known history of the other members what the characteristics of the missing member of the family must have been. It is thus as to atoms. It was not long ago when Mendeljeff said that if certain vacancies in his tables of atoms were ever filled, they would have to be filled by elements possessing certain chemical and physical properties which he accurately specified. Since that time these vacancies have been filled, and by atoms or elements possessing the very properties which Mendeljeff said they would possess. Galium was discovered by Lecoq de Boisbaudron, scandium by Nilson, germanium by Winkler; and these discoverers agree that the atomic, chemical, and physical properties of these substances agree exactly with those predicted by Mendeljeff. It sometimes happens that the real parentage of an element has been lost altogether, but a careful examination frequently enables the chemist to restore it to the family to which it belongs. Such discoveries as these have brought physicists, perhaps as a class, to regard all substances as having one common origin. In reference to this Huxley says: "In the living world facts of this kind are now understood to mean evolution from a common prototype. It is difficult to imagine that in the not-living world they are devoid of significance. It is probable that they mean the evolution of our elements from a primary undifferentiated form of matter."

It is probable that the majority of scientists regard atoms as spherules of force. The vortex-ring hypothesis is, that atoms are but permanent whirlpools or vortices of ether, and that their peculiar properties depend on their actual and potential motion. The ether is supposed to be a universal and uniform substance. On this hypothesis alchemy is not altogether a dream; the philosopher's stone not a mere wild speculation, but a possibility which at any time might be realized. If it be not realized, it is not because of any difference in the underlying something which constitutes the various atoms, but because these different bodies, although formed out of a like primary substance, may have been formed under very different conditions, which conditions may be no longer obtainable. Says Huxley, "The idea that atoms are absolutely ingenerable, and immutable, 'manufactured articles,' stands on the same sort of foundation as the idea that biological species are 'manufactured articles' stood thirty years ago." In reference to the constitution of matter Spencer says: "All material substances are divisible into so-called elementary substances composed of molecular particles of the same nature as themselves; but these molecular particles are complicated structures consisting of congregations of truly elementary atoms, identical in nature and differing only in position, arrangement, motion, etc., and the molecules or chemical atoms are produced from the true or physical, by processes of evolution under which chemistry has not been able to reproduce them." Mr. Norman Lockyer thinks that there is good evidence for believing that in the sun and other such heavenly bodies our elementary substances exist in a still more elementary state, in other words that though the primary something out of which our substances have been formed are in the sun, yet our elements themselves are not found there. Says he, "a terrestrial element is an exceedingly complicated thing that is broken up into simpler things at the temperature of the sun, and some of these things exist in some sun-spots, while other constituents exist in others." Says the late Sir Benjamin Brodie, in a lecture delivered before the chemical society, in 1867, "We may conceive that in remote time or in remote space, there did exist formerly, or probably do exist now, certain simpler forms of matter than we find on the surface of our globe, such as α, χ, ξ, ν, and so on. We may consider that in remote ages the temperature was much higher than it is now, and that these other things existed then in the form of perfect gases — separate existences — uncombined. We may then conceive that the temperature began to fall, and these things to combine with one another, and to enter into new forms of existence, appropriate to the circumstances in which they were placed. We may further imagine that as the temperature went on falling, certain forms of matter became more permanent and more stable, to the exclusion of other forms. We may conceive of this process of the lowering of temperature going on so that these substances when once formed, could never be decomposed — in fact that the resolution of these bodies into their component parts could never occur again. This is not purely imaginative, for when we look at some of the facts which have been revealed to us by the extraordinary analyses which have been made of the matter of distant worlds, and nebulæ, by means of the spectroscope, it does not seem incredible that there may even be evidence, some day, of the independent existence of such things as χ, ξ. and ν."

Professor Stokes says of a certain line in the nebulæ that it may indicate some form of matter more elementary than we know on earth. Probably chemists as a class to-day regard the so-called elements as very stable compounds of more elementary substances or substance. In 1868, Graham spoke of Sir William Thompson's vortex rings as an hypothesis that "has brought matter into individual existence"; and Dr. Gladstone says that "the elements have been built up from one another, according to some general plan." Crooke says: "It seems natural to view existing elements not as primordial, but as the gradual outcome of a process of development, even perhaps of a struggle for existence." This is coming over to the doctrine of the ancients, such as that of Empedocles: "Φύσις οὐδενός ἐστιν, ἀλλὰ μόνον μίξις τε διάλλαξίς τε μιγέντων — Everything that is," he says, "is from one substance; the many forms are the result of mixture and change." (Aristotle: De Gen. I. 1.)

In the solar spectrum we find one line characteristic of a substance of which we have no knowledge on earth. The substance which gives this line is believed to exist in abundance in the chromosphere of the sun. Some physicists have given to this hypothetical body the name of helium. In a paper read before the Academy of Brussels the Abbé E. Spée said that if helium exist, it enjoys two very remarkable properties. Its spectrum consists of a single ray, and its vapor possesses no absorbing power. This non-absorbent power seems to be an exception to a well-known physical law; but Professor Tyndall has shown that the absorptive power increases with the complexity of molecular structure. This would lead us to infer that the simpler the molecule, the feebler the absorption. The Abbé Spée regards this conclusion as perfectly legitimate. One has not to strain his imagination much to see in such a simple substance as helium something very near to the primordial element out of which all our so-called elements have been generated. Dr. Carnelley thinks that all our elements with the exception of hydrogen have been evolved out of two simpler elements, such as $A = +12$ and $B = -2$. Of these he regards A as a tetrad identical with carbon, and B as a monad of negative weight, perhaps the ethereal fluid of space. But from the fact that Dr. Carnelley supposes that hydrogen, carbon, and the ether are primary elements out of which has been spun the fabric our elements now present us, we are not to infer that he believes in three or even two really primary elements. The three elements which he infers are primary elements, he would probably say have also been evolved out of some unknown and absolutely simple substance or force. Perhaps under this hypothesis, it were sufficient to say that the conditions under which these simpler elements, specially carbon and hydrogen were evolved and became stable in their character, are more remote from us; and their dissolution, therefore, the more improbable under the existing physical conditions; although he would probably believe it scientific to hold that given the original conditions, the embryotic state of the universe, and these elements so-called would again lose their elementary character, being dissolved into their original state. In other words, our most elementary substances are in truth but molecules, although under the existing physical conditions it may be beyond the power of any chemist to decompose them. Dr. Mills also supposes that all the elements were once in a simple and pristine state, and that as so-called elements they are the result of successive polymerisations. This successive polymerisation results, he thinks, from the passage of the pristine matter from one extreme of temperature to another. In the passage of this pristine matter through such a vast range of temperature it would arrive at certain critical points, at which our so-called atoms might be generated. "Let us imagine," says Professor Crookes, "that at the primal stage all was in an ultra-gaseous state at a temperature inconceivably hotter than anything now existing in the visible universe, so hot indeed that the chemical atoms could not yet have been formed, being still far above their dissociation point. In so far as protyle is capable of radiating or reflecting light, this vast sea of incandescent mist, to an astromomer in a distant star, might have appeared as a nebula, showing in the spectroscope a few isolated lines, forecasts of hydrogen and carbon and hydrogen spectra. But in course of time some process akin to cooling, probably internal, reduces the temperature of the cosmic protyle to a point at which the first step in granulation takes place; matter as we know it came into existence and atoms are formed. As soon as an atom is formed out of protyle, it is a store of energy, potential from its tendency to coalesce with other atoms by gravitation or chemically; and kinetic from its internal motions. To obtain this energy the neighboring protyle must be refrigerated by it, and thereby the subsequent formation of other atoms will be accelerated. The easiest formed element is first born." This element, and several near it in simplicity, are in our judgment entirely unknown, and likely will remain unknown. In eternity the steps of time are marked off by aeons; but in the evolution of the cosmos the time came when the conditions were such that hydrogen, our simplest known element, was born. Between the birth of this, our simplest known element, and the next, there may have been a wide gap, have intervened a great length of time, during the latter part of which the element next in order of simplicity would be slowly approaching its birth-point; pending this period we may suppose that the evolutionary process which soon was to determine the birth of a new element, would also determine its atomic weight, its affinities, and its chemical position. In the original genesis, the longer the time occupied in that portion of the cooling down during which the hardening of the protyle into atoms took place, the more sharply defined would be the resulting elements; and, on the other hand, with more irregularity in the original cooling we should have a nearer approach to the state of the elemental family such as we know it at present. Before the birth of atoms all those forms of energy which become evident when matter acts upon matter, could not have existed, — they were locked up in the protyle as latent potentialities only. "Coincident with the formation of atoms all those attributes and properties which form the means of discriminating one chemical element from another began to assume gradually greater stability. Definite quantities of electricity was an elementary attribute of each element the moment of its birth. On these quantities its atomicity depends, and the types of monotomic, diatomic, triatomic, and tetratomic elements are fixed."

Helmholtz thinks that electricity is as really atomic as any other matter; and some suppose that it and the ether are two of the more original elements, or those forms of matter which are the least differentiated.

Nor is science convinced of the absolute and invariable weight of any of the atoms, as is quite generally supposed. A couple of years ago one of the foremost physicists of the world read a very learned paper maintaining the contrary. He regards the atomic weight of the atoms as the general average weight from an almost infinite number of variations. As we cannot see in the rainbow just where one color ends and another begins; so with the atoms, we cannot tell just where the division line is between the one that precedes and the other one that follows. The passage from the state which constitutes one atom to that state which constitutes another, is by infinitely small increments or differences. Thus there is no real break between hydrogen and lithium, as there is not between red and orange; but as in the latter case the difference between the two colors is manifested by their extremes, so in the case of hydrogen and lithium their passage from one to the other is by an insensible gradation which cannot be detected by any finite power; yet the extremes of the two states are sufficiently different to be appreciated, and to be called by different names. In other words, the atoms are related to one another as the animal world, or even as the vertebrata. We can readily detect the difference between the lowest and highest forms of animal life classed under the branch vertebrata; but could we see every form of this branch that has lived, it would doubtless be found that in the evolution of this branch the passage from one form to another has been by such infinitely small gradations, that none could tell just where one form ended or another begun. Earth gives us the remains of a few of these gradations; but where one has been preserved to tell the story of this passage, hundreds of thousands have returned to the elements out of which they were made without leaving any visible record of their existence. It is perhaps to be wondered at that with the action of time and the great convulsions of nature, the earth has preserved as many as we find; but, then, Nature is quite a faithful mother. She at least never forsakes her children.

> "O Nature! holy, meek, and mild,
> Thou dweller on the mountain wild;
> Thou haunter of the lonesome wood;
> Thou wanderer by the secret flood;
> Thou lover of the daisied sod,
> Where Spring's white foot hath lightly trod;
> Finder of flowers, fresh-sprung and new,
> Where sunshine comes to seek the dew;
> Twiner of bowers for lovers' meet;
> Smoother of sods for poets' feet;
> Thrice sainted matron! in whose face,
> Who looks in love will light on grace;
> Far-worshipped goddess! one who gives
> Her love to him who wisely lives;—
> Oh! take my hand and place me on
> The daisied footstool of thy throne.
> And pass before my darkened sight
> Thy hands which let in charmed light;
> And touch my soul; and let me see
> The ways of God, fair dame, in thee." (Cunningham.)

That our so-called elements do not differ in their true essence or being, one from another, one might readily infer, although not deeply versed in physical science. Every time we behold the centre of our solar system, or any other of the vast suns rolling in space, we can hardly suppress the question, What has brought me this sensation? What is a ray of light? Is it substance or simply motion? If substance, what shall we call it? What are its properties? If motion, what is it motion of? Through what medium does it vibrate? He that has taken only his first lessons in optics, knows well that light is not substance, but motion. Now, motion is force; and matter and force are inseparable. The fact therefore that a ray of light passes from the stellar world to us, should convince us that the space between us and those worlds is full of some form of matter through which the waves of motion constituting the rays of light, pass. In this substance the stellar worlds themselves must float, and the smallest atoms vibrate. The fact of the transparency and translucency of so many bodies may give us some perception of the fineness of the particles that constitute this medium; and the further fact that physicists, notwithstanding their vast researches, know absolutely nothing of this medium, except that it must of necessity exist, would lead us naturally to infer that it must be of a much less complicated structure than any so-called elements we are acquainted with. In speaking of pure substance, the clear-headed Locke says: "If any one will examine himself concerning his notion of pure substance in general, he will find he has no other idea of it at all, but only a supposition of he knows not what support of such qualities, which are capable of producing simple ideas in us. If any one should be asked what is the subject wherein color or weight inheres, he would have nothing to say, but the solid extended parts; and if he were demanded what is it that the solidity and extension adhere in, he would not be in a much better case than the Indian who saying that the world was supported by a great elephant, was asked what the elephant rested on; to which his answer was a great tortoise. But being pressed to know what gave support to the broad back tortoise, replied something he knew not what. And thus here, we use words without having any clear and distinct ideas; we talk like children." The medium we have been speaking of, is called the elastic ether. It is believed to fill every interatomic space; and the ethereal atoms, in order to convey light and electricity, must swing with inconceivable velocity. Surely, it would seem reasonable to see in such a substance, or force, something near to the true essence out of which our so-called atoms have been evolved. It may be fruitless to make such inquiries; but with Tyndall we must say: "It may be questioned whether a mind trained in physical research, can at all enjoy peace without having made clear to itself some possible way of imagining those operations which lie beyond the boundaries of sense, and in which sensible phenomena originate." In speaking of the ether this learned physicist says in another place: "A medium embraces our atoms; within our atmosphere exists a second and a finer atmosphere, in which the atoms of hydrogen and oxygen are like suspended grains. This finer atmosphere unites not only atom with atom, but star with star; and the light of all suns, and of all stars, is in reality a kind of motion propagated through this interstellar medium. This image must be clearly seized, and then we have to advance a step. We must not only figure our atoms suspended in this medium, but we must figure them vibrating in it. In this motion of the atoms consists what we call their heat. Motion in this form, unconnected with ordinary matter, but speeding through the interstellar medium, receives the name of Radiant Heat; and if competent to excite the nerves of vision, we call it light."

A thorough study of the nature of substance, or atoms in general, will lead one to the conclusion that in the universe there is but one truly elementary principle out of which by a process similar to that of evolution in the organic world, all the various forms and manifestations of matter and force have been evolved. And with this conclusion there will come a conviction that the true life, spirit, soul, force, essence, and guiding power of this universal and only elementary principle, can be none other than a Universal Being, Infinite in all its perfections. This Being is the Universal Essence and Life, by which all existence is, and through which only it can continue to be. This is the Being whom all nations and peoples and tongues rightly enough call Father, and whom alone we ought to worship as God forevermore. The so-called laws of nature are but modes of this eternal, universal and immutable Will. It is this fact that makes the student of nature trust and love her and, when his very life seems oozing out of him, longing for faces he will see no more, to appeal to her for sympathy in the words of that sweet poet of nature:

"Flow gently, sweet Afton, among thy green braes,
Flow gently, I'll sing thee a song in thy praise;
My Mary's asleep by thy murmuring stream—
Flow gently, sweet Afton, disturb not her dream.

"Thou stock-dove, whose echo resounds through the glen;
Ye wild whistling blackbirds in yon thorny den,
Thou green-crested lapwing, thy screaming forbear,
I charge you, disturb not my slumbering fair.

"Flow gently, sweet Afton, among thy green braes,
Flow gently, sweet river, the theme of my lays;
My Mary's asleep by thy murmuring stream—
Flow gently, sweet Afton, disturb not her dream."
(Burns.)

CHAPTER XIII

ATOMIC AND MOLECULAR WORLDS CONTINUED

THAT the force constituting an oak tree is only an aggregation of the forces which constitute an atom, we have no reasonable doubt whatever; but an atom is not an oak. In my work, "God and Man," on pages 211, 212, the following words occur: "What then we ask is this essence which must be common to both? It is certain that if this essence be neither so-called matter nor so-called mind, whatever it may be, it must be unknown to us. This unknown essence must be the Substance, the Cause, of all things. In this unknown Essence must so-called matter and so-called mind have their common unity, their true being; and in it must subject and object be united. What then shall we call this Essence? We answer, since it can be neither so-called matter nor so-called mind, and yet must be the true Essence of all things, we may call it the Ultimate Reality, the Universal Substance. To this ultimate Substance must be referred all the phenomena of mind and matter; and in it must all existences blend, and have their true being. It must be the womb of all the forces in the universe; it must be the Thinking Monon, the Universal Intelligence, the Universal Will; and in this Universal Monon must the body and soul of the universe be united. Here and here only can we find the explanation of so-called matter and so-called mind, and more than all of man's will." To these words written about twenty years ago, and for writing which I was deposed from the ministry of the Episcopal Church, I am not able to add any improvement; and from them I would not take one iota. An atom of so-called matter may not appear to the unphilosophical to have anything in common with so-called mind; but we may be sure there is a close relationship between them. We look at the sides of a triangle, and perhaps know that the sides *A* and *B* subtend an angle of 30°. The sides *A* and *B* are seen to be specifically different; but on a closer inspection they are each seen to arise from a common point, a common origin. At first they are not to be distinguished, nor can we detect the point itself in which they originate; but as they grow wider apart, we become able to distinguish them, and we call them *A* and *B*. Thus is it with mind and matter; they are phenomena arising from, or branching out of, the same common origin or force. This origin we do not, nor is it likely we ever shall, know. As we know the sides of the triangle and not the point of origin; so we know mind and matter, which are but two sides of the same thing, having their common origin in a point, or substance, or force unknown to us, and, as I believe, forever unknowable to finite intelligence. This Universal Being or Substance will become more and more known to man, as the ages roll by, and he has time and opportunity for study and contemplation; but that it will ever be fully known to us, philosophy forbids us to hope.

To him acquainted with the tell-tale interdependence of mind and matter, belief in their essential unity is sure to follow. As has been said, "We are a plaything to every pressure of air." Even our very moods, and intellectual power depend on the quality and quantity of food we eat. Says Haeckel: "Our mental activity, the activity of our understanding and of our imagination, is quite different accordingly as we have taken tea or coffee, wine or beer, before or during our work. Here as everywhere the variations of the mind go hand in hand with the corresponding transformations of the body; both are produced by purely material causes." That these physiological facts have not been unknown to the churches, it is sufficient to refer to the fasts imposed on their members, and to the peculiar kinds of food they have been and are directed to eat; and all this on the grounds that such rules and regulations, if complied with, lead us to a sense of sin, and to a more devotional life.

As the word atom was coined to represent the smallest particle of matter in existence, or a mere point of force; so the word molecule is used to represent the smallest portion of matter that can exist in a free state. If we represent the molecule by a building, each stone in the building would represent an atom. A house is built of stones, and a molecule is built of atoms; as a house may be demolished, so may the molecule; the one not unfitly represents the other.

I have said that a molecule is the least particle of matter that can exist in a free state. For instance, if you put into a glass-tube two volumes of hydrogen and one of oxygen, the gases will remain perfectly mixed, but will not cohere. But should you touch the mouth of the tube with a lighted taper, the two gases will immediately combine, causing an explosion, and forming water. If electricity be passed through the gases, the same result will take place. Now, the smallest particle of water imaginable will have the same number of volumes of these gases, namely two of hydrogen and one of water. Therefore we say that a molecule of matter is the smallest portion that can exist in a free state.

Again, if you put into a bottle equal volumes of hydrogen and chlorine gases, and throw it into the air, so that it may be struck by the actinic solar ray, you will hear a violent explosion, the gases having combined to form hydrochloric acid. Of the acid thus formed it will again be found that however inconceivably small a portion you examine, it will contain one atom of chlorine and one of hydrogen.

The molecule is therefore the smallest portion of matter that can exist in a free state. The solitary atom is like the human being necessarily forced, on the presentation of the first opportunity, to associate itself with others. Aristotle tells us (Politics I, 2, 9) that man is a political animal, "Ἄνθρωπος φύσει πολιτικὸν ζῷον"; and in another place (Politics I, 1, 2) that it is necessary for man and woman to unite their lives in order to prevent the disappearance of their own species: "Ἀνάγκη δὴ πρῶτον συνδυάζεσθαι τοὺς ἄνευ ἀλλήλων μὴ δυναμένους οἷον θῆλυ μὲν καὶ ἄρρεν τῆς γενέσεως ἕνεκεν." When brought face to face with the physical facts of the case, the chemist is almost led to infer a like social feeling existing in atoms, and by a little larger stretch of his imagination, he might suppose that with them too there exists a not altogether dissimilar necessity for union. Binet, the eminent specialist of Paris, shows how many of those acts considered most peculiar to the genus homo, are strikingly exemplified in the actions of animalcules, giving us as example the feigned indifference or even repugnance of the female mastigophor to all the blandishments of the knightly male; how with the protozoa as with man, the male, working on the principle that a faint heart never won a fair lady, and using every possible means to secure the desired end, finally captivates the female mastigophor, leading her off to the great discomfiture of all her other aspirants. This same scientist commenting on the observations made by Berthold on the conjugation of the zoospores of the Ectocarpus siliculosus, says, they evidently go through an extended period of courtship; that a multitude of males pay their addresses to one female, and use every art to win her; that finally all but one, finding no hope of ultimate success, quit the field. With a knowledge of these facts who can withhold his assent to the assertion that "Sexual selection acts among spermatozoids just as among all animals" ? (Binet.) Here, then, we find psychic manifestations of no low degree exhibiting themselves even in the protozoa, and in a more elementary form in protozoids or vegetable reproductive elements. Says Binet, "Even on the very lowest rounds of the ladder of life, psychic manifestations are very much more complex than is usually supposed. By the aid of exact data we have shown that in both vegetable and animal micro-organisms phenomena are encountered which pertain to a highly complex psychology, and which appear quite out of proportion to the minute mass that serves them as a substratum."

One of the most remarkable forms of animal life is that discovered by Huxley, and obtained from deep-sea bottom, and which he called Bathybius. This moneron exists as naked lumps of protoplasm and recticular mucus.

Psychic phenomena manifesting themselves in these momentary existences, these mere points of organisms, it does not appear unscientific to hold that potential life, and all the phenomena attending it, from the government of an Oklahoma village to that of the British empire, exists in the atom itself, even in the atom of hydrogen or helium. Potentially I say, not actually. The crowing of the cock, the cackling of the hen, the intellect of an Aristotle, the genius of a Shakespeare, and the superstitious reverence of an Ignatius Loyola all exist potentially, though not actually, in an egg. On this ground very many atomic phenomena, not otherwise easily explained, are capable of ready solution. And while we may not have conclusive scientific reason for regarding atoms as living substances, it is more certain still that we are unable to say where life begins in the forces of nature. Says Goethe, that great German soul, "Matter can never exist and be active without mind, nor can mind exist without matter"; and says Haeckel, "The idea of the unity of organic and inorganic nature is now firmly established. . . . All natural bodies which are known to us are equally animated, and the distinction which has been made between animals and inanimate bodies does not exist." Concerning those persons who will not admit this truth, this scientist says, "They throw themselves into the arms of a poetic faith which can have no value in the domain of scientific knowledge."

Among the first to grasp this monistic conception of the universe was Democritus, 500 B. C., who is considered by many the real founder of the atomic theory, which was put for the first time upon a truly scientific basis by that eminent English scientist Dalton. For giving voice to this monistic conception of things poor Bruno was burnt at the stake by the Christian church, February 17th, 1600; but he was not the first nor the last to suffer persecution for righteousness sake; a notable example of those who thus suffered was then living in the person of Galileo, who was exactly thirty-six years of age on the day of Bruno's martyrdom. Said Giordano Bruno: "A spirit exists in all things, and no body is so small but contains a part of the divine substance within itself, by which it is animated." It is this noble and loftiest idea of God immanent in nature that made Goethe say, "Certainly there does not exist a more beautiful worship of God than that which needs no image, but which arises in our heart from converse with Nature."

The great laws relating to the unions of atoms are few in number and may be thus summed up:

1: The relative weights according to which bodies combine are invariable for each combination; or each of the elements combines with the others in a fixed and definite proportion by weight. This is called Dalton's first law.

2: The weights of the combining volumes of the gaseous elements bear a simple ratio to their atomic weight. This law was discovered by Guy Lussac.

3: The law of multiple proportions: When two bodies simple or compound unite in several proportions to form several compounds, the weight of one of these bodies being considered as constant, the weights of the others vary according to a simple ratio. This law was discovered by Dalton. For instance:

Nitrogen	monoxide	contains	for	28	parts	of	N.	16	parts	of	O.
"	dioxide	"	"	28	"	"	"	32	"	"	"
"	trioxide	"	"	28	"	"	"	48	"	"	"
"	tetroxide	"	"	28	"	"	"	64	"	"	"
"	pentoxide	"	"	28	"	"	"	80	"	"	"

These numbers 32, 48, 64, 80, are multiples of the first—that is of 16.

Again, when the atomic weight of any atom is compared with that of hydrogen as unity, or when the density of any gaseous element is compared with that of hydrogen as unity, there is found to exist a simple ratio. This was pointed out by Guy Lussac. Such a relation has led many, and might readily lead us, to see in hydrogen something near to the real element out of which the other atoms have been formed.

The force which presides over chemical combinations, is called chemical affinity; and it is in the exhibition of this that atoms act so much like the forms of higher organisms. To illustrate: Oxygen has but little affinity or atomic love, call it which you please, for copper, under general conditions; but as in the case of higher beings when you array them in their best, and make them as alluring as possible, so here,—if you heat the copper in the air oxygen will immediately rush to it, and with it form oxide of copper. Their affinity for each other is now so great that they cannot be divorced, under ordinary circumstances. But even now if you mix this oxide with powdered charcoal, and then heat the mixture, a moment arrives when the affinity of the charcoal for the oxygen is greater than that of the copper, causing the oxygen to forsake the copper and unite with the charcoal to form carbonic acid. The allurements of the charcoal suffice at last to cause the oxygen to leave its first love, and go with its new affinity. We see similar action often in the case of men and women. Again, the attraction of hydrogen for oxygen is very great under ordinary circumstances, causing them to live in the greatest harmony, as, for instance, in water; but as at times a third party is seen to insinuate himself into a household, destroy its peace, and ultimately break up its union, so here if an atom of potassium, for instance, finds its way into a molecule of water, the peace of the molecular family is at once destroyed and jealousy and a murderous quarrel ensue, the metal burning brightly, and darting hither and thither on the surface of the water, exulting as it were in the mischief it works. In this contest of atomic affinity or love, the potash wins the day, taking away with itself two blushing damsels for its harem, and leaving an atom of hydrogen like the last rose of summer to droop and die of a broken heart.

The atoms that combine to form a new family or molecule do not absolutely touch one another, because each atom, being a point of force, must have a certain portion of space to vibrate in; but comparatively speaking the spaces that separate the atoms of a molecule one from another are reduced to zero by chemical affinity. As in the highest manifestations of consciousness, so in the atomic world, affinity sweeps all before it, being satisfied with nothing less than oneness of life. The spaces between contiguous molecules are much greater than those between contiguous atoms; for molecules are bound together by the force of cohesion, while atoms are bound together by that of chemical affinity. The difference between chemical affinity and cohesion is similar to that between mere friendship and a real union of hearts. Still, as each heart, however closely united to another, must have some room for independent act and thought, so has every atom its own little orbit of motion independent of the movement of the molecule as a whole. These spaces are supposed, and very properly so, to be full of ether, a substance near to the original force out of which this mighty fabric of a universe has been spun. Between the centres of contiguous molecules which form a liquid, a transparent or seemingly opaque solid, Sir William Thompson has estimated the distances as being less than one hundred-millionth and greater than two thousand-millionth of a centimetre. Even in such a compact mass as sulphide of iron, the atoms are in constant vibration, always, however, keeping their relative positions unchanged, and the molecules are comparatively far apart.

The spaces between atoms and molecules must not be confounded with those between the portions of a mass which make the body porous; for porosity is a far different thing, it being but the accidental spaces which form visible pores in solid bodies.

As in the family too great independent action, or the striving after individual rather than joint welfare, must inevitably bring disruption of family ties, so in what is termed the inorganic world, excessive atomic or molecular activity brings disruption of the whole. In the family the assertion of excessive individuality may follow inflamed passions, and this is not without its parallel in the inorganic world. If you heat a solid body, the force thus applied expends itself partly in raising the body's temperature, and partly in increasing the distances which separate the molecules and atoms. As the heat is continued this independent molecular activity increases until the force of cohesion is almost entirely overcome. The molecules begin to slide freely over one another, as in the liquid state, no longer keeping their relative positions. In this state they move not unlike a straying comet or wandering star, or a human being who allured by the charmer, is on the very verge of forsaking both consort and children. If the heat be further increased, the molecules grow wider and wider apart until they move about independently of one another, as they do in the gaseous state, where each tries to possess the whole territory for itself.

As union of hearts does not always follow association or even marriage, such union requiring in general internal forces to produce a wish for it, and a consciousness of its usefulness; so in the inorganic world mere association of particles does not always produce chemical union. If you reduce iron to a powder and mix it with sulphur which has been similarly reduced, it will present neither the gray-black of finely divided iron nor the lemon-yellow color of sulphur. Now, as one unacquainted with the facts of the case might infer a speedy marriage from seeing young people frequently together; so on looking on this mixture the unskilled might believe that the sulphur and iron have married, entered into combination, formed a new compound. But should he take a microscope he might readily detect the sulphur and iron each minding its own business. However intimate their conversation, or deep their courtship, it will be evident to such an observer that they have not entered into a lasting wedlock. As in the case of mere companionship, a little shaking up, a few petty quarrels, suffice to sever the bonds of friendship; so in the case of the mixture of iron and sulphur. If you throw both into the water, each is seen to save itself, and separation is complete, the sulphur allowing the iron to sink to the bottom alone, and there remain in its watery grave. But as in the case of young people, if you encourage their acquaintance, and make marriage appear a gain to both, wedlock will probably ensue; so in the case of the triturated iron and sulphur mixed together; if you heat this mixture the sulphur will be seen first to melt, like a young lady unable to withstand further the tears and groans of her lover; then the whole mass will blacken, if the temperature be sufficiently elevated; and after cooling the substance will be found to be perfectly homogeneous. No power now can discriminate the iron from the sulphur. Both have disappeared as such, having formed a new substance known as sulphide of iron.

Should this new substance be weighed, it will be found to contain the exact weight of both the sulphur and the iron; and this is characteristic of all chemical combinations: nothing is ever lost whatever transformations it may pass through.

If now this sulphide of iron be allowed to remain in a damp atmosphere, an efflorescence will be seen to collect on its surface composed of a saline matter. The sulphide of iron has here attracted to its family-life certain other individuals. Like a sultan, or Abraham, Isaac, and Jacob of old; so the iron, not being content with one young damsel, takes to itself four others, fair as the moon in its fulness, in the persons of four atoms of oxygen from the air, forming what is known as green vitriol or sulphate of iron.

We have seen from what has been said that chemical union does not generally follow mere juxtaposition; heat is generally necessary. But as heat is in general the condition of chemical union, so is excessive heat destructive of it. Heat in chemical combinations is like oxygen with us: it is at once both life-giver and destroyer of all that exist. With this in our mind it will be easier for us to comprehend the great subject of cosmology; nor will it be so difficult to understand the slow process of world-building, knowing the impossibility of chemical union under the conditions which must have prevailed for countless æons before the then existing chaos became a sensible cosmos. As in temperate zones civilization best flourishes, so chemical union is most active with no extremes of temperature. With excessive heat atomic individuality is excessively asserted; with excessive cold the atomic freedom is almost swallowed up in its servile subjection to molecular power. From this fact we may learn that as the earth was countless ages before its temperature was sufficiently reduced to permit of chemical union for world-building; so in the distant future, its temperature having fallen below the point which permits of active chemical combination, will it exist for countless ages in a state of absolute equilibrium or death, before it plunges into the sun, already enfeebled with age, for a baptism of fire, or before with its frozen heart, and wandering in black and frozen regions, it meets some other world dead like itself, and by their awful compact, shaking the very pillars of heaven, elevate themselves into a single spherical gaseous globe which in the ages that may follow, will again give birth to world after world, and to civilization after civilization; for while the breath of man is but vapor, and all his joy and sorrow fill but a point of space, the very atom that we pass on the street in contempt, is stamped with almost eternal life. It is sad indeed to think of the time when the good and great, the true and beautiful, fail to greet us and tremble with pleasure in our presence; yet, when we know the many cares of life, and that death at least brings rest to all, and a hoped-for higher life, we should not too excessively mourn the departed, nor fear for ourselves the approach of death. Without any doubt death is a part of the order of nature, and therefore a real good, whether it be the end of man's individuality, his metempsychosis, his change into some other form of being, or his entrance, as some believe, into a glorious immortality.

We here give a table of the elements as known to-day. In the first column is given their names; in the second, their valency; in the third, their atomic weight.

Aluminium	iv	27
Antimony	iii v	12
Arsenum	iii v	75
Barium	ii	137
Beryllium	ii	9
Bismuth	iii v	209
Boron	iii	11
Bromin	i	80
Cadmium	ii	112
Cesium	i	132.5
Calcium	ii	40
Carbon	iv	12
Cerium	ii iv	140
Chlorin	i	35.5
Chromium	iv	52
Cobalt	ii	59.1
Copper	ii	63.2
Davyum	?	154
Didymium	iii v	144.5
Erbium	iii	166
Fluorin	i	19
Gallium	iii	69
Germanium	ii iv	72
Gold	iii	196.7
Hydrogen	i	1
Indium	iii	113.4
Iodin	i	126.5
Iridium	ii iv	191
Iron	ii iv	56
Lanthanum	iii	138
Lead	ii	206.4
Lithium	i	7
Magnesium	ii	24
Manganese	ii iv	55
Mercury	ii	200
Molybdenum	ii iv	95.5
Nickel	ii	58.6
Niobium	v	94
Nitrogen	iii v	14
Osmium	vi	190.2
Oxygen	ii	16
Palladium	ii iv	106
Phosphorus	iii v	31
Platinum	iv	194.3
Potassium	i	39
Rhodium	ii iv	104
Rubidium	i	85
Ruthenium	ii iv	104.2
Samarium	iii	150
Scandium	iii	44
Selenium	ii iv vi	79
Silicon	iv	28
Silver	i	108
Sodium	i	23

Strontium	ii	87.5	Titanium	iv	48
Sulphur	ii iv vi	32	Tungsten	iv	184
Tantalum	iii v	182	Uranium	ii	238.5
Tellurium	ii iv vi	125	Vanadium	iii v	51.3
Terbium	?	148.8	Ytterbium	?	173
Thallium	i iii	204	Yttrium	iii	89
Thorium	ii iv	231	Zinc	ii	65
Tin	ii iv	118	Zirconium	iv	89.5

The above elements are also classified into families, depending on similar characteristics; such as boron nitrogen phosphorus arsenum antimony bismuth gold, which are classified under the nitrogen group; and iron manganese aluminum chromium nickel cobalt, which are classified under the iron group.

Late Additions to the Elements

Argon	39.6	Lutecium	172.6
Columbium	92.76	Neodynium	143.15
Dysprosium	161.2	Neon	19.8
Gadolinium	156.05	Phraseodynium	139.48
Glucinum	9.03	Radium	224.6
Helium	4.	Thulium	167.16
Krypton	82.34	Xenon	129.66

CHAPTER XIV

THE ORIGIN OF OUR COSMOS

SCIENTIFIC men have speculated for three thousand years concerning the origin of that portion of the universe called the solar system. Of the many speculations given to the world, none has become so celebrated, nor taken such hold on scientific minds, as that known as the nebular hypothesis. In some form or other it is universally accepted to-day; and it has stood every test since the days of Kant, Herschel, and LaPlace. Nothing is known in science to militate against its truth; and every day the hypothesis is only strengthened through the labors of mathematicians, geologists, and astronomers. It is no more nor less than applying the principles of evolution to the origin of the solar system. The ancient philosophers thought nothing could be more rational than this; and certainly to-day we are forced to confirm their thought. If it be admitted that God works according to the principles of evolution in bringing into being the various form of terrestrial existences, it is most reasonable to infer that he so works everywhere and always, as a being infinite in all his attributes must be the same to-day, yesterday, and forever.

The fact that the nebular hypothesis is held to be a most reasonable explanation of the origin of the existing cosmos by the most eminent scholars of the world, is enough in itself to demand for it our most serious attention; for what such minds as theirs conceive, must not be cast aside with contempt.

We all know that the planets with their satellites move around the sun; that the primary planets all move in the same direction, and all the satellites with the exception of those of Uranus and Neptune; that all the planets move very nearly in the same plane; that the equatorial planes differ but slightly from one another; that this coincidence is more exact as the periods are greater. With the exception of Mercury and the asteroids, the plane of none of the planets differs from that of the earth more than three degrees. The deviation of the sun's equatorial plane is only seven and half degrees, that of Jupiter only about half as much. It may also be said that, as far as we know, all the planets that have an axial rotation, rotate on their axes in the same direction as that in which they move around the sun—that is, from west to east. Now, it is not believed that such coincidences as these could be possible, if the planets were not originated on one general plan. It was the knowledge of these known facts that led master minds to give to the world, or at least confirm, the theory known as the nebular hypothesis. To us blest with the labors of celebrated scientists, there may seem to be nothing wonderful about such a theory of the world's origin; but we may be sure that it needed master minds to frame such an explanation, and test its truth with every canon known to science. For thousands of years there were men who arrived at very similar conceptions, although through lack of modern knowledge, they failed perhaps to put their thoughts into exact form. Thus although the nebular hypothesis in its more exact scientific form is comparatively modern, for over three thousand years there have been scholars who have held that a reasonable and perfectly scientific explanation of the origin of the solar system may be found in the process of evolution. And standing on this process science holds to-day that in the beginning the matter now composing our solar system, and most of that yet diffused in the inter-planetary space, existed in one mighty globular mass whose centre was in our sun, and whose periphery was far beyond the utmost boundaries of Neptune's realm. When we say "in the beginning," we do not mean in the beginning of matter; for science holds this to be eternal, without beginning or end. But by this phrase we mean in the beginning of our solar system or of our cosmos. It is held that there then existed a mighty globe filling all the space now ruled by our sun; that this nebulous matter was homogeneous in character, atoms having not yet been evolved. There was but one form of matter; and this form would have remained unchanged forever, were it not that different environments brought about different conditions in the various parts of the universal fire-mist; for, as time rolled on, the results of different velocities and different radiation brought about unlike environments; and these forced matter to assume different forms to suit the changed conditions.

The density of this globe of fire-mist or whatever we may call it, must have been inconceivably small, since its mass was perhaps not much greater than that of our present cosmos; although it filled all the space which our sun and planets now fill, and depths of space immeasurably greater. This fire-mist, however, was not infinite, and therefore it must have had a surface, which must have been exposed to the outer regions of space; and this surface thus exposed would necessarily part with its heat more readily than its interior. As it lost heat it would necessarily condense and contract. By some it is held that in this contraction we have all that is necessary to account for the first axial movement of this fire-mist. By others it is questioned if the first movement of such a globe could so originate. Such philosophers hold that the fire-mist must have received its axial rotation from the equatorial motion of the cosmic vapor which previously had generated the globe of fire-mist. However, it does appear that from the fall of myriads of particles towards the centre of this globe, there would result a want of equilibrium, and that therefore the body would finally begin to rotate. He who does not accept this view may adopt the other, namely, that this fire-mist out of which our cosmos has been generated, had an original axial motion imparted to it from some preceding cosmic vapor or world-forming stuff, from which it had originated in the æons gone by.

Having this fire-mist with its original or derived axial rotation, we have now only to assume what certainly must have occurred — namely contraction. As this body contracted, its axial motion would increase according to a well known law of mechanics, known as the conservation of areas. When a system of bodies or particles revolving around a common centre changes its form, the sum of all the areas described by such bodies or particles around their common centre, in any given time, remains the same or constant, and this sum is called the areolar velocity. Supposing the mass were reduced to a diameter of one-third its former dimensions, the area of any plane section through its centre would be only one-ninth of its former area; for such areas are proportional to the squares of their radii. In such case as this if the angular velocity remains the same, and the radius is decreased to one-third the original, the centrifugal force would be only one-third; and if the angular velocity is increased nine times, the centrifugal force will be eighty-one times the original. Thus from the changes in the radius and the velocity we shall have as the full result a centrifugal force twenty-seven times the original. In the meantime the gravitational force has increased only nine times. The increase therefore in the centrifugal force is to that of the gravitational as 27 is to 9. Thus we have a loss of balance between the centrifugal and the gravitational forces, and therefore a tendency especially for the equatorial matter of the fire-mist to fly off. Thus would form rings or meteoric bodies, which would revolve around the parent ball. Although because of the contraction the gravitational force at the equator would be increased nine times (the square of three), at the poles on the other hand gravitation would be unaffected. The result of this would be necessarily an alteration in the character of the fire-mist; instead of being globular it would become flattened at the poles. Little by little would the denser portions of this world-forming material fall toward the plane of the equator, and in time congregate together, as happens with milk when one churns butter. This process would keep on until the formation of a large body or bodies, as the continual agitation of milk results finally in the formation of butter; and as the motion of these fire-mist particles would not be interfered with by their condensation, it follows that the bodies thus formed would revolve around the central part of the fire-mist ball as the planets revolve around the sun. It is probable that in this manner the rings of Saturn were formed; and it is equally probable that it was thus our moon had its birth in the earth, and every other satellite in its primary. That it was thus our planets arose from their primary—the nebulous mist or world-forming stuff, we have every reason to believe.

The above view of the nebular hypothesis is a somewhat modified form of the original. By Kant it was held that the motion of the fire-mist ball would result in the throwing or dropping off from its equator of ring after ring of matter, which would condense into globular bodies, which in turn might throw off from their equators similar rings of matter to form moons or satellites, the bodies most distant from the centre being first formed. At the present day it is doubted by some if such results would or could follow the motion of the fire-mist ball. It is held by some scientists that the unmodified hypothesis of Kant and LaPlace does not afford a perfect explanation of the generation, order, and movements of the planets of the solar system. Yet it must not be supposed that any astronomer rejects the evolution of the solar system from one common fire-mist or whatever we may call it. They all undoubtedly believe that the solar system was so generated; but many hold to modified forms of the one common nebular hypothesis. The modification most in accord with the original hypothesis is that in which it is held that the fire-mist ball became from its motion and condensation flattened out into a number of nebulous rings, all concentric. These rings or thin flat disk would in time break up into a series of rings, each of which would condense, and form a planet, much as LaPlace supposed. But whereas LaPlace held that there was a great difference in the ages of the planets, and that the planets most distant from the sun were first formed; in this modified hypothesis it is not believed that there must be any great difference in the ages of the different planets. Another modification of the nebular hypothesis is that in which it is supposed that the matter of the fire-mist ball condensed into particles, which would form centres or nuclei, as the particles of milk condense and form nuclei in the churning of butter. Around these centres would congregate or gravitate the matter of the fire-mist; and thus would be evolved the sun, the planets, and their moons.

That we know in what form or by what process the cosmos was evolved, is not near so important as that we know it was evolved naturally, in order, and in accordance with established laws; and by this we mean, without any such act as is generally denominated "special providence" or "special creation." Thinking men of all ages past and present, and scientists of every shade of opinion, hold that the cosmos is not a result of special creative power, but one of evolution. By what process of evolution it was evolved, different scientists have had and do have different opinions; but that it must have been naturally evolved, the whole scientific world affirms. Here as in the organic world the peculiar mode of its evolution is not so much insisted on as the fact that it has had an orderly and regular development. Says Newcomb: "The widest induction of modern science agrees with the speculations of thinking minds in past ages, in presenting the creation of the material universe as a process rather than an act. This process began when the present material universe was a mass of fiery vapor, filling the stellar spaces; it is still going on in its inevitable course, and it will end when sun and stars are reduced to cold masses of dead matter. The nebular hypothesis is indicated by the general tendencies of the laws of nature. It has not been proved to be inconsistent with any fact; and it is almost a necessary consequence of the only theory by which we can account for the origin and conservation of the sun's heat."

It may appear a difficulty to some in accepting the nebular hypothesis, why some planets should be so much more dense than others, if there be no necessary differences in their ages. The explanation of this difficulty is found in the fact of the great disparity in the sizes of the planets. It is certain that the smaller bodies would lose their heat much sooner than the larger ones. What is not explained through the difference in size, can be on the supposition of greater initial heat; for it would be indeed highly improbable that every planet would leave the parent globe at precisely the same temperature.

Stating more briefly the facts which have led philosophers to adopt the nebular hypothesis, or some such evolutional theory, we find:

That the sun, the centre of the system, rotates on its axis from west to east;

That all the primary planets, as far as we know, move in their orbits from west to east;

That the planes of the planetary orbits differ but little from that of the sun's equator;

That the densities of the planets are very nearly proportional to their nearness to the sun;

That all the satellites move in their orbits, and on their axes, from west to east, with the exception of those of Uranus and Neptune; and the anomalies here found do not really constitute an objection to the nebular hypothesis. The motion of a satellite around its primary, must depend on the axial rotation of such primary; and the axial rotation of a body may, and probably does, largely depend on forces resident within it; and such forces may have given to the primary an axial rotation from east to west rather than from west to east, although its orbital motion around the parent fire-mist be from west to east, in agreement with the axial rotation of the primary nebulous ball. If it were known that Uranus or Neptune moved on its axis from west to east, while their satellites move in their orbits from east to west, there might be found something apparently subversive of the nebular hypothesis; but even then we doubt not that astronomy would eventually find an explanation accordant with the nebular theory. It is affirmed by the most competent that provided the axial rotation of a satellite be in the same direction as the orbital motion of its primary, the nebular hypothesis is satisfied. This is true also in the case of any derived or secondary body with reference to its primary. It is generally held that, so far as we know, this requirement is fulfilled among the bodies of the solar system. If in time it shall be found that the axial rotation of Uranus or Neptune be in an opposite direction to the orbital motion of its satellites, there may be need of a further modification of the nebular hypothesis; but however this hypothesis be modified, nothing will ever move the firm faith of the scientific world that the cosmos is simply the result of an orderly development; that as the rose is but a continual modification of or evolution from the first roots of the little tree upon which it blooms; so the beautifully arranged structure we call the solar system, is but a modification of or an evolution from the primeval fire-mist, and this too according to the same laws as prevail in the cosmos to-day, without let or hindrance.

Our globes are certainly the condensation of diffused matter which once extended throughout the whole solar system, and perhaps to the extent of many hundreds of millions of miles farther from the sun than is the outermost boundary of the orbit of our most distant planet to-day. This condensation or conglomeration is not as yet complete, but still progressing. It must not be supposed that the space between the sun and Neptune for instance contains nothing but the few planets that in the dead silence of nature perform their ceaseless tasks in revolving around their centre that rules with a rod of iron the subjects of his kingdom. On the contrary, it is certain enough that space, especially the portion we now speak of, is full of partly fine, and partly coarse portions of matter. Any person who wishes to prove this, can do so any clear night; for he will not have long to wait before he will see a meteor of some kind. The enormous number of meteoroids that daily fall to the earth is not beyond the possibility of calculation, as we have shown in the chapter on meteors. The great extent of space throughout which the sun rules, must not therefore be considered as being occupied by a few planets only; for as we have seen, in addition to these massive bodies, many of which rule under the sun as feudal lords under their king, there are millions of millions of lesser bodies whirling incessantly through the same space, and making obeisance to the same mighty tzar.

In addition to these latter bodies the existence of a luminous ether is not considered doubtful; for as in science, and with the educated man, there is no room for witchcraft nor demonology, some medium must be postulated for the transmission of the motion which produces in us the sensations of light and heat. The hypothesis of the existence of a luminous ether would seem to find strong corroboration also in the fact that it is necessary to infer the existence of some such medium in order to account for the peculiar motion of Encke's comet, which is known to be circulating around the sun in ever diminishing orbits. Sir William Thompson has attempted to calculate what the resistance of this luminous ether must be. He has found that its density is far less than that of the air in the most perfectly exhausted air-pump; but that it has nevertheless a positive value. A volume of space equal to that of the earth can not, he thinks, contain less than 2775 pounds of luminous ether. On this basis you would find on calculation that the mass of all the planets known to us, with that of the sun combined, would be small compared to the mass of luminous ether whioh extends throughout the space in which the planets roll.

In the original formation or generation of the heavens the abundance of diffused matter, caused perhaps by the shock of other clashing worlds, heating them to a gaseous condition, worlds which may have existed millions of millions of years before the derivative out of which our solar system was formed, made such generation or evolution a comparatively easy matter, as it is not difficult to reap a sheaf in a field of waving golden grain; but once these worlds were formed, the picking up of stray matter became more difficult, as to gather a sheaf is difficult in a field that has been cut and raked. But still the gleaners do not work for nothing, nor do the planets as they move; but they glean the fields in their courses by adding to their masses the myriads of meteoroids they meet in their paths. It is not an empty space therefore in which the planets move, but one full of life and activity.

There is something sad as well as inspiring in the contemplation of the works of nature. Life so full of action, and at times almost intoxicated with pleasure, though much more frequently writhing with pain, or blasted with disappointment, never ceases to be sung and discussed in poetry and philosophy; but Death though it pains not, nor makes the cheek pallid and sunken from starvation, the fireless eye and haggard look from anxiety, nor kills with disappointment and woe the heart once so young and hopeful, — Death has but few to sing his praise, or crown his head with laurels, but thousands to execrate and hate him. This is much to be regretted, for nothing is more natural than death, not even the evolution of the solar system under natural law; and whatever is natural should be submitted to with willing submission: we should meet Death as we go to our daily toil, or to our places of repose. In death man undergoes no peculiar change; it is one common to the whole cosmos, and to every particle within it. All things are born; all things grow old; all things die; all things change. It is certain as it can be that in this regard man is a fair photograph of the cosmos, the mother which produced him: as man is born full of life, yet stamped with death; so too the cosmos itself, so pregnant with living force, manifests everywhere as many certainties of future death, as evidences of present life. As with man the means of supplying his depleted energies gradually fail, so with the planets, the chief source of their power will fail to supply their life-giving currents; their pulse shall beat slower and slower; their eyes shall lose their wonted lustre; their step its elasticity. For a few thousand years they shall live on in decrepitude, "sans teeth, sans eyes, sans taste." Finally their great heart, the sun itself, shall no longer be able to pump the life-giving current through their centres of being. Then must come to pass that which is written on the face of every organism and world — death. The worlds shall die, and be buried in space; they must remain buried for years or millions of years, until collisions with some other dead worlds, or some other mighty resurrection force, shall raise them out of their graves. When this shall happen they shall rise in an instant from their deep sepulchres to begin once more lives of youthfulness and beauty.

The question may be asked, if there is anything in nature which might bring to a sudden end the existence of our solar system. As in the case of man there are many diseases which may at any time cut short his activity, and consign him to forgetfulness; so in the case of the planets and the solar system, or any other system, there are forces or diseases which might bring them to a like sudden end. It can not be but that there are bodies, stars, suns, dead worlds, whose orbits bring them across our system in such a manner as to disarrange possibly the whole structure, or to collide with sun or planets. In such a case the end of our system would be sudden. It is not doubted that there are dead suns; indeed, there may be many more dead than living. Even in known living stars or suns there seems to be evidence that such disruption or ruin awaits us. Some stars have very irregular proper motion. Of these we may mention 1830 Groombridge, the run-away star, which has the largest proper motion of any known star. It is said that this body moves with such awful rapidity that the gravitation of all the stars can not stop it, until it shall have passed through and beyond the confines of the visible universe. Its parallax is given as about one-tenth of a second. Yet this star has an apparent motion of about seven seconds a year. This means that the space this star passes through in one year is more than seventy times the distance of the earth from the sun. This gives it a velocity of more than 200 miles a second; which is so great that even though there were twice as many stars as appear to us with the most powerful telescope, and each had an average mass five times greater than our sun, and moved in a sphere that it would take light thirty thousand years to cross, yet a body could not acquire it, though it had fallen from an infinite distance. Says Newcomb: "Either the bodies which compose our universe are vastly more massive than telescopic examinations seems to indicate, or 1830 Groombridge is a run-away star flying on a boundless course through infinite space with such momentum that the attraction of all the bodies of the universe can not stop it." Now, it is not probable that 1830 Groombridge stands alone; the probability is that there are vast numbers of such stars. Can it be possible that some of these stars dead or living may not have a course across our system! And if such stars should cross our system, can it be doubted that they might either totally disarrange the whole structure, or collide with our sun, or some one or more of its satellites!

Even from the history of our solar system we may be certain of the possibility of such collisions. The collision of two or more worlds or masses brought into being, in all probability, the fire-mist out of which the solar system has been evolved; or the collision of worlds brought into existence the cosmic nebula from which the nebula was derived out of which our system has been generated.

The motions of the planets of our system are not unlike those of so many race-horses. They move in concentric orbits, and probably without much danger of collision; but should some racer rush across the race-course, there is certainly much danger of a catastrophe. In the case of the solar system the danger is always proportional to the size of the body which crosses it. In the case of a large living or dead sun rushing across our path, the danger would be imminent, and of disarrangement certain enough.

The stability of the solar system, or of any other system, is poetry not prose. "It is subject to fears within and conflicts without"; and can never call its life its own. Yet the probability is that it will roll on in about the same order it is now in; that we shall die and be gathered to our fathers, leaving the same sun and moon and stars to shine over our children that shine now over us. But still the end must come sooner or later. The solar system must die of old age, disease, or violence; but whatever be the future of the cosmos, its origin and development have been according to law. This assures us that after our cosmos shall have ceased to be, the universe shall still abide forever young and fruitful, the fountain of all life and activity.

It is no more absurd to hold that existence is not or was not than that form or mode is eternal or permanent. Our cosmos is only a mode or form of eternal existence; and this mode or form is as readily and surely to be dropped as it was assumed. The earth has no right, nor has any other child of the sun, to claim eternal life; nor does it even pretend to; nor has it a single characteristic of permanence. Our solar system, parent and offspring, are but forms or modes of existence, and as such are temporal. None of these differs from us except in degree. While real being has forever been, and shall forever continue to be, its forms are never permanent. These are assumed for the gratification of finite intelligence. The cosmos must die, and be buried as we, and as deeply; but its substance as our own shall remain fecund as of yore, and in time shall clothe itself again with new and equally glorious forms, showing every finite intelligence the boundless power, wisdom, and goodness of the Infinite Whole.

CHAPTER XV

THE VARIOUS SYSTEMS OF THE UNIVERSE

IN studying the different systems entering into the grand whole, as far as we know them, the chemical system may be called the most elementary. This is a system composed of two or more chemical atoms. Infinitely small as these little worlds may be, they are not at all, in their motions, unlike the largest system in the cosmos. They rotate on their axes; they have electric currents, polar forces; they move in orbits as suns or planets; they move around one another or a common centre; and like that of the largest worlds their substance is indestructible and ingenerable. Infinite as may be the transformations they pass through, they are in every higher sense the same yesterday to-day and forever, without end or beginning. The molecule of alcohol or of sulphuric acid presents us a system as complicated as that of the solar system, and not less wonderful. As bodies they act and interact, pass and repass, attract and repell, shun the society of some and seek that of others; and they build up, and as far as mortal man can know, keep in order the system to which they belong, as if their little cosmos were presided over, as we believe it is, by intelligent forces.

The next higher cosmological system is found in elementary life. This in plants and animals is beyond question the same. It is only in the evolution of the higher forms that differentiation begins between the fundamental vegetable and the fundamental animal life. The determination of this identity has been the work of biological science, a branch of investigation wherein science has made most wonderful discoveries the past century.

What is life may be subject of dispute; but it is far from true that we are no better able to answer this question to-day than last century. For ourselves we hold that life is immanent in substance; and we think it may be safely stated that modern science does not believe that it needs a truly organized structure for the manifestation of life. It is true we do not recognize conscious stones, nor conscious trees; but this does not prove that life is not universally diffused, and that the whole of nature is not indeed and in truth alive. We do not recognize this manifestation with our blunt senses; but this is not because it is not there. It is rather because we lack a higher intelligence, and sufficiently acute sensation. We are unable to detect light until it is sufficiently strong to excite our organs of vision, or sound until it is sufficiently loud to excite our organs of hearing. We stand in the dim light of a dark room unable to pick up anything should we drop it; but were all the light in the room collected and focalized, we might have sufficient light to pick up even a pin. Again, the acoustic properties of a place may be such that a whisper will cause quite a loud sound to be heard. Thus is it with all the forces of the universe; thus is it with life. The life of nature may be said to be latent, diffused, unfocalized, and therefore insensible; but when it appears in a speck of protoplasm, life is as it were focalized, intensified, and become therefore immediately manifest or sensible. We listen to the slightest touch of the harp, and probably fail to hear any sound; but as the instrument is struck with more force, we hear the harmonious vibrations. We look at nature for the manifestation of life in general, and fail to see it; but as nature intensifies her modes of manifestation, we behold her full of life, and hear her full of harmony. Says Haeckel: "We thus arrive at the extremely important conviction that all natural bodies which are known to us, are equally animated, that the distinction which has been made between animate and inanimate bodies does not exist."

The basis of animal and of vegetable life is a cell; and the highest plant or animal is nothing but a multiplication of these cells. In a vegetable cell there is the nucleus, and the inner and outer cell-walls. "The nucleus is a small body usually of lenticular or sub-globose form, and of albuminous composition, that lies imbedded in protoplasmic substance, either on the cell-wall, or in the central cavity. The inner wall is essential to the existence of the cell; it is called the primordial utricle; it is extremely thin and delicate, and it is not sharply defined, but passes gradationally into the protoplasmic substance it incloses, from which it is chiefly distinguished by the absence of granules. The outer layer or wall consists entirely of cellulose which seems to be excreted from the surface of the ectoplasm for the protection of its contents; it is usually thick and strong, and can often be seen to consist of several layers." This is the unit of vegetable life, and there is nothing in the highest vegetable but a multiplication of these cells or units. But the cell itself is a highly complicated system consisting of numerous molecules composed of atoms working in harmony, and permeated with intelligent force. The fundamental unit of all animal tissues is the cell. Animal cells vary in diameter from 1/3200 to 1/200 of an inch. Every cell is composed of a cell-wall full of protoplasm, containing generally a nucleus, and exhibits all the basic properties of life: it eats, digests, secretes, excretes, generates, and has motion. The cell therefore is the lowest form of animal life.

Next above the cell comes the amœba. This is a little lump of protoplasmic matter with a kernel. It has an endosarc and ectosarc clearly distinguished; and a nucleus which is adherent to the inner part of the ectosarc, from which it projects into the part occupied by the endosarc.

It has neither mouth nor outlet. It generates by division of itself. When this little speck of protoplasm is hungry, it makes an opening into its body for the entrance of any digestible matter; and when such matter has passed within, the amœba closes the opening, thus surrounding the captive, and completely digesting it. The body of the most highly organized animal, such as man, is but a multiplication of these cells. In discharging the different functions of the body they have differentiated into modified forms, as best suited to the work to be done; but in every essential sense a man is neither more nor less than a colony of cells. So also is our mode of nutrition very similar to that seen in the amœba. It is true enough we take food into the stomach; but this is only the beginning of nutrition: the real work remains to be done by the elements of our constitution; and in deed and in truth it is performed in us as in the amœba. Every man is therefore a system of forces. In him we see, first, elementary atoms, as it were planets; then a system formed out of these atoms, as it were a solar system; then a system of systems, as it were a stellar system,—all working together to produce one grand cosmos—man. All these various systems sink their individualities in the one individuality; their separate consciousnesses, in the one greater consciousness.

In all these systems of forces whether it be that of animal or vegetable life, we have everywhere evidence of volition, choice, forethought; in short, of what we call mind; and he that does not see the whole immanent with intelligent force, must be lacking the intelligence necessary to see it.

In the simple planetary system we have a world or worlds moving around a ruling centre; and in the sun or star system we have worlds, accompanied by their satellites, moving around a gravitational centre. Such systems are necessarily complicated as a molecule of alcohol; and there is need of order and regularity to save from confusion and destruction. That some one system has greater dimensions or is more massive than another, does not prove that it is more complicated or important. Hercules morose and sullen, lying in his tent, burning with rage because of ungratified lust, was not a more complicated organism than the smallest member of the Grecian army encamped before the walls of Troy. Nor was Agamemnon either more important or complicated than the vastly smaller but nobler Iphigenia. It is neither dimension nor mass that necessarily makes superiority; but rather function, and perfection of the organism.

Every system such as the solar may be called a cosmological system, because of the many bodies composing it, and the order and regularity manifested in all its parts both small and great; but truly it is no more cosmological than is a molecule of starch, or a physiological unit of the butterfly.

As the cell is the fundamental unit of so-called life, so is the molecule the unit of so-called material masses; and each of these units gives every evidence of acting intelligently and wisely. Man is easily deceived because of mass or dimensions; but this is only proof of his weakness and ignorance. As in the stellar systems so deeply buried in the vast depths of untrodden space, we speak of wonders which the unaided eye of man can never behold; so is man equally impotent when he seeks to behold the mysterious worlds that form the molecules, or the wonderful molecular systems themselves. To which of these systems, so-called great and small, shall we give the greater glory? The philosopher answers, to neither. The infinitely little is no less glorious than the infinitely great, nor are its mysteries any more revealed, nor the nature of its being, nor its origin and end.

We have all seen the "Milky-way," the galaxy, stretched across the broad expanse of heaven. It has somewhat the shape of a disk or plate of rather irregular outline; and was thought by Herschel to lie in a plane related to the stars as the plane of the ecliptic is related to the planets. At either of the galactic poles the stars are very few in number; but increasing in numbers in proportion to the distance from the poles, midway they are very thick, even huddled together, as it were, and piled in heaps or clusters one upon another. The stream is divided from Cygnus to Scorpio; and its diameter is thought to be eight or ten times its thickness. Our sun is a star not far from the centre of this disk-like space or stratum. In studying this wonderful stream of stars Herschel thought he found black spaces leading into impenetrable darkness, as it were the end of the universe; so Maunder speaks of having detected "dark lanes" in the Milky-way.

In the Milky-way are seen some beautiful star clusters. The one best known is the Pleiades, revealing to the naked eye from six to thirteen stars; and on a photographic plate, after exposure for seventeen and half hours, no less than seven thousand. The finest telescopic cluster in the northern heavens is that known as 13 M Hercules, one of several thousands of stars of vivid and various colors.

Other striking celestial objects are the nebulæ. Of these more than ten thousand are now known. Some of these are shown by the spectroscope to be composed of glowing gases, especially of hydrogen; others are found to be made up of masses of stars, so deeply buried in the profundity of space as to appear all piled one upon another. Perrine says that not less than 500,000 nebulæ can now be reached through the great reflecting telescopes, and photographed.

Of the principal nebulæ we may give the ring nebula in Lyra; the spiral nebula in Canes Venatici; the Great Nebula in Orion; and the Great Nebula in Andromeda. It is to this last nebula that Kapteyn likens the shape of our stellar system, placing our sun in the disk-shaped nucleus.

Herschel considering the stratum of stars called the Milky-way, thought it a layer or bed circular in shape, and having but little thickness compared to its breadth. He supposed this bed to be split near its southern edge, the two parts being separated as if by a wedge. Near the point of separation he places our sun; and this point is named the "sun's way."

Mädler held that the stars of the galaxy form an immense ring, or several rings one within another. An observer situated within these rings would see one ring within another; and thus the stars would appear too numerous for computation; while towards the poles of the rings few stars would be seen. According to Mädler our sun is situated within this ring or these rings, not in the centre, but nearer the southern portion; wherefore the south-east portion appears to us most bright. He holds that these rings do not lie exactly in the same plane; but that at the south they diverge into two streams, the divergence appearing greatest at the side nearest to us.

Astronomers have labored to calculate what the dimensions of the galaxy must be; and although such calculations must have in them very many elements of uncertainty, it is believed that the most remote parts of it can not be less than 2300 times the average distance of stars of the first magnitude; and that light must take somewhere about 20,000 years to cross from one side of this galaxy to the other. The thickness of this stratum of stars is supposed to be equal to about 80 times the distance of the nearest fixed star.

Both Mädler and Herschel hold that our sun is a member of this starry stratum or galaxy, whose dimensions and numbers are so vast as really to be beyond the highest imagination of man. Young says: "It is perfectly certain that a cross-section of the Orion nebula must be at least many thousand times the area of Neptune's orbit." Stars can be seen through the most powerful telescope so far away that light from them takes at least forty-eight thousand years to come to us. Lord Ross, Herschel, and many others have succeeded in resolving many of the nebulæ. Such are found to be aggregations of countless numbers of stars so far away that they are held by some to be other distant galaxies. To what an awful distance must these be removed we may judge by calculating how far we should have to recede before our galaxy, of which our solar system is but an insignificant member, would appear as a spot or smoky vapor a few inches broad. It must take millions of years for light to come from these galaxies to our earth.

In area the nebulous spots are said to cover about 1/250 of the whole visible heavens. It is thought that the passage of light from some of these spots requires millions of years. Great as is the distance of the extreme boundary of the galaxy, it is small indeed compared to this. Some of the nebulæ are now known not to be so far away as has been thought; especially is this true of those spots shown by means of the spectroscope to be nothing but glowing vapors or gases. The nebulous mass in the constellation Cancer, right ascension eight hours and twenty minutes, declination 20° 10′ north, is plainly visible to the naked eye on a clear night. This mass is named Praesepe, and is resolved by the telescope into brilliant stars. Another wonderful star-cluster is found in the constellation Perseus. This appears to the unaided eye as a faint patch of light, but in the telescope as a wonderful aggregation of stars. It is situated in right ascension two hours and ten minutes, declination 57° north. In Centaurus a very rich cluster is found appearing to the unaided eye as a dim nebula. It is shown in the telescope to be composed of stars too numerous to count. In speaking of this cluster Herschel says: "This noble globular cluster is beyond all comparison the richest and largest object of the kind in the heavens. The stars are literally innumerable." Another beautiful object is 47 Toucani. Speaking of this, Herschel says: "It is a most glorious globular cluster, the stars being immensely numerous. It is compressed to a blaze of light at the centre." The most milky-looking of any of the nebulæ, that in Andromeda, gives a continuous spectrum, showing it to be composed of true stars. We have already stated that Kapteyn likens the shape of our stellar system to this nebula. In the southern heavens, near the pole, are situated the two Magellanic clouds, the larger called Nebecula Major, the smaller Nebecula Minor. The telescope reveals these as heavenly wonders. In these clouds very many star-clusters are seen; also nebulæ separate, and in groups. In the great cloud no less than 580 single stars are counted, 46 star-clusters, and 291 nebulæ.

Nothing can be imagined more wonderful than these star-clusters. So great are their distances that in many cases the most powerful telescopes ever invented reveal them only as faint patches of star-dust, making it impossible to distinguish one star from another. Thus their distances are beyond any possibility of measurement, and imagination itself seems to be altogether outdone. Yet in all probability these are systems which are vastly grander than our own; and perhaps supply the possibilities of life and activity to countless billions of intelligent beings to many of whom we may be merely intellectual pigmies.

Many of the nebulæ are matter in a purely gaseous state; and may be imagined in some instances to be the stuff out of which future worlds are to be formed.

Every star is a sun, and probably has its planets and satellites as has our own sun; and while these vast suns composing our primary stellar system thus roll through the unfathomable depths of space, they probably carry with them vast numbers of worlds full of intelligent beings subjects of incessant activity, and laden with anxiety and sorrow. What a precious cargo carry these wonderful worlds along! We speak of the cargo of a vessel or of the souls on board of an express-train; but what are these compared to the infinite number that Nature has placed under the protection and guidance of the suns of our universe! Without headlight, without rails, without engineers or firemen, without fuel to burn or oil to ease the friction, they yet run on for millions of years, and never fail to run on time. Never troubled with strikes nor tie-ups, never spreading a rail nor breaking a tire, they perform their work harmoniously, beautifully, and happily, everywhere giving evidence of a government wise, strong, and beneficent.

The universe of which these wonderful systems are a part, is without end or beginning; disturbed more or less with commotions from the very atom to the aggregation of systems; yet though manifesting constant variations and transformations, remaining, in every essential sense, the same yesterday to-day and forever. "The universe is eternal and immeasurable in both space and time. It is eternal and it is infinite. Nor can we imagine a beginning or end to the uninterrupted and eternal motion in which all particles of the universe are eternally engaged. The great laws of the conservation of energy, the foundation of our whole conception of nature, admit of no other supposition. The universe, as far as it is cognizable to human capability, appears as a connected chain of phenomena of motion, necessitating changes of forms. Every form, as the temporary result of a multiplicity of phenomena of motion, is as such perishable, and of little duration. But in the continual change of form, substance and the motion inseparable from it, remain eternal and indestructible."

Man may boast of his greatness, but the thoughtful soul can not fail to realize that he is scarcely a factor in the great whole of which he forms such an insignificant part. So may we be prone to form hasty conclusions concerning the nature, order, and limits of the universe; but the true scholar recognizes the fact that we have only a glance of the magnificent whole; that we have scarcely passed the threshold of the most perfectly built and the most luxuriously furnished mansion, the universal cosmos, whose architect and builder is surely an infinitely good, wise, and universally immanent Deity.

To the thoughtful soul the world is full of revelations. Every day to such a person is as a new page in some fascinating book. As it is the custom of some readers to look over the last page or two of a book, before they really begin to read the work; so the thinking man is not unfrequently moved with a burning desire to know what nature has in store for him, after this short life is over. But such a person is not unconscious of the fulness of the joys which nature has here in store as a reward for the faithful studies of the earnest student. Every inch of earth is full of ten thousand beauties; every inch of sky is a worthy object of study; and the depths of space are crowded with the most wonderful and fascinating objects for study and contemplation. The philosopher learns that nothing is truly insignificant. The mirror but reflects our own image; so our judgment of the wonders of nature is after all but the reflection of our minds and hearts. To the thoughtful there is perhaps no less worthy object of study in the growth of a crystal than in that of a human being; no less in the structure and movements of a molecule than in that of some star-cluster. The thoughtless person is not attracted by the appearance of a blood corpuscle; but he can not refrain from wonder, when he sees it through a microscope. Systematic study, a long course of physical research gives the student a kind of microscopic and telescopic power. He sees with different eyes, hears with different ears, and feels with different nerves from those he once possessed. How grand and godlike did the studies of Herschel make him! How greatly are the generations which follow him, blessed through his labors! He seems no longer a son of man, no longer a citizen of England; but a true child of God, a true citizen of the universe. He was as much at home on some lonely peak in South Africa, as in the metropolis of the world; he appeared as well acquainted with the stars, as with the lilies of the field. Thus in our studies: they should teach us to feel our unity with the whole; to know the universe as one grand exhibition of infinite power, without beginning or end; but everywhere moving with the same divine life, and guided by the same divine and immanent intelligence.

When man is compared to this infinite whole, or his life to the movement of a star-cluster or galaxy, how insignificant it appears! Generation after generation riseth up and passeth away, and is seen no more forever; nations flourish and fall into dust like Assyria, Babylonia, Greece, and Rome. But these stupendous parts of the One Living Universe at whose great heart-beat a myriad ages roll by; these stupendous time-keepers that seemingly never grow old, run down, or need repairing, these swing on in their orbits, beating time to the march of eternity, while man and nations, and empires, as meteors, appear and disappear in the twinkling of an eye, falling into oblivion and deep forgetfulness, out of which they shall rise no more forever.

CHAPTER XVI

THE UNITY OF THE UNIVERSE

ONE of the first wonders that attract the infant eye, is the starry heavens above us; and of the very many studies which are known to give most delight to man, it is difficult to find any more delightful than that of astronomy. It is this more than all others that opens the universe to our contemplation, enabling us to go from world to world, and fix its position in space, measure its rate of motion, define its kind, and weigh it in the astronomical balance with mathematical precision.

By the word, universe, we sometimes mean the grand totality of nature, other times that part of it which more especially concerns us,—in other words, our sun and all those distant worlds belonging to the same system. In common usage this is called the galaxy. As there can not be any comparison of the finite with the infinite, it would seem foolishness to compare our universe, great as it is, to the grand totality. It is awful for the human mind to contemplate a boundless space filled with an infinite number of worlds in all stages of perfection, some in their chaotic condition, some just born, some in their childhood, some in their youth, some in their manhood, some in old age, some on their death-bed, some in their graves, while others are passing through their resurrection state. But awful as it is to think of such a universe, yet the thinking soul can not resist the temptation to frame to himself some idea respecting the origin, condition, and future state of such a grand totality. We may certainly say that compared to such a mighty whole our universe is but an atom. Our universe proper may very well be called a universe-molecule, having for its atoms dependent systems of suns and planets. Our solar system makes but an atom of this molecule. When in thought we connect this atom with the countless other similar systems composing the galaxy, we have the first universe-molecule. Could man stand on the outer side of the galaxy, and have sufficient range of vision, he would doubtless see the heavens above him glistening with shining points every one of which being a galaxy composed of myriads of suns each the centre of vast revolving worlds bursting with life and intelligence.

Though we confine in general our thoughts to our universe, it must not be supposed that we imagine any other part of the grand totality to be governed by any other laws, or to be in any essential sense at all different from our own. In science we frequently raise the consideration of some one branch of scientific investigation to the rank of a specialty, such as chemistry, or anthropology, not because of the superior worth of these studies, but because of man's inability to grasp the whole at once. The fact that there is a science of chemistry and of anthropology, does not warrant us in holding that chemistry is anything more than one of the physical sciences or that anthropology is something independent of zoology, or that man is anything more than a member of the animal kingdom, produced and governed by general laws. The scientist does not behold in Nature what the poet does. He sees no blind chance, no miracles, no fate, unless you call perfection by that name. To the scientist the whole of Nature is permeated with law relatively eternal, immutable, and harmonious; and this he demonstrates by rigid mathematical calculations reaching back many thousand years. He is not disposed to quarrel with Nature, since he knows that such an act would be but quarreling with himself, inasmuch as he is a part of it; and if he believes that Nature is synonymous with God, he would not dare to find fault with her, lest in doing so he might be found guilty of blasphemy.

As Nature is the grand totality of so-called material and spiritual forces, so is every part of it a natural production; for the different parts of Nature are not essentially new or different, but only new arrangements or modifications of the old. To us therefore the universe proper is one and the same from eternity to eternity. As the little universe, man, may in one day present modifications of himself, and in a lifetime various phases, such as childhood, youth, manhood, old age, sickness, health, life, and death; thus is it with every part of the mighty changeless whole: each and every part is subject to constant change; one form cometh up and another passeth away; one cloud gathereth and another scattereth; but the oneness of the whole still remains unbroken. Putting this doctrine of science in another form, we say that the total amount of energy in the universe is unchangeable, being the same to-day as it always has been, and as it will always continue to be. With this truth, that the sum total of the energy in the universe remains the same forever and ever, agrees the now universally received doctrine, the persistence of force, or the conservation of energy. This in truth is not, as some suppose, a new doctrine; Aristotle taught it about 2300 years ago in the following words: "*ἀλλ' ἀδύνατον κίνησιν ἢ γενέσθαι ἢ φθαρῆναι· ἀεὶ γὰρ ἦν.*" (Met. xi, 6, 1.) Of this law Farady says: "It is the highest law in physical science which our faculties permit us to perceive"; and says Newcomb, "In our scientific philosophy, the doctrine that force can not be annihilated is coequal with that that it can not be created; and the inductive processes on which the later doctrine is founded are almost as unimpeachable as those from which we conclude that matter can not be created" (Astronomy, 514); and Spencer says, "The truths that matter and motion are unchangeable in quantity, are implications of the truth that force is unchangeable in quantity." (First Principles, 539.) It is certain that the whole structure of modern science, is built upon this doctrine; and it is furthermore equally certain that without an understanding and an acceptation of this doctrine, no one can make any headway in real scientific knowledge or investigation.

The convertability of the different forces of Nature, is called in science the correlation of forces. Science says that all the changes which manifest themselves to us, are but mutations from form to form; an impulse of force can no more be created than a particle of matter destroyed. Says Clerk Maxwell, "The total energy of any body or system of bodies is a quantity which can neither be increased nor diminished by any mutual attraction of such bodies, though it may be transformed into any one of the forms of which the energy is susceptible"; and says Huxley, "Energy like matter is indestructible and ingenerable in nature."

Much is being said about the substance radium; but truly there is nothing mysterious about it—no more than there has been about many other physical discoveries. If it be true that in one gramme of radium there are one billion calories or units of force, it is also true that when this force is expended, there is no more radium; and if it be true that one gramme of this substance will give off energy for ten thousand one hundred years, it is also true that at the end of that time the radium has been totally radiated or transformed into other forms of matter. This is in perfect accord with the universally received doctrine of the correlation of energy; and therefore there is nothing mysterious about it.

If a gramme of hydrogen and eight grammes of oxygen be exploded, they will make nine grammes of water having a temperature of 136.5° C.; and if this be cooled down to water at 0° C., there will be 34,462 calories of energy liberated; and if eight grammes of oxygen combine with one of hydrogen in the nascent state, there will be produced 54,623 calories. It is true this is not a billion; but the billion calories are just as natural a transformation as are the 54,623.

The diameter of the hydrogen molecule, says Loschmidt, is .00000004 of a centimetre, and the radius of its molecular action is .00003 of a centimetre. This gives a vibratory motion to the molecule equal to 1500 times its diameter in the solid elastic universal ether. Just imagine what a force this inconceivably small point of matter must have to vibrate such length! In one cubic centimetre there are, according to Maxwell, 19,000000,000000,000000 atoms; according to Crookes, 1000,000000,000000,000000 atoms; and according to Sir William Hamilton, not more than 6000,000000,000000, 000000. The mean free path of molecular vibration increases according to rarification. At ordinary temperature Crooks gives the mean free path of hydrogen as one ten-thousandth of a millimetre. Now, with a Sprengel air-pump the atmospheric pressure may be reduced to the one hundred-millionth. With this pressure the hydrogen molecule would have a free path of 33 feet. At a height of 210 miles or more there are not more than 1000 hydrogen molecules to the cubic centimetre. At this altitude the hydrogen molecule might travel, through a uniform space, 60,000,000 miles without colliding with another molecule; and in the depths of space there is believed to be the possibility of such free movement, that it might travel, without collision, for the number of miles denoted by 19 followed by 314 ciphers.

Thus matter seemingly so solid to us, is on the contrary extremely discontinuous. Every molecule is a vibrating system, sometimes of small trajectory, sometimes of vastly large. These vibrations are in a solid medium, the universal elastic ether, necessarily absolutely homogeneous or near to the Substance that is. In the essential motion of the molecule the ether may impart action to it, just as naturally as the earth to the grain imbedded in it; and the vibrating molecule may, possibly, impart motion to the ether; but this last does not so naturally follow: the grain must die to impart action to the earth. Upon this motion does the atom depend, as some say, for its existence; but it were better said, for its form. If its motion were lost, it would revert to unknown conditions, or perhaps to the Universal Substance. Thus there is nothing mysterious in radium. It is a form of compact energy in an unstable condition; and possibly in its dissolution receive increments of energy to its own original supply through impact or juxtaposition with the universal elastic ether.

We get a somewhat correct idea of the universe and of the invariability of its energy from conceiving it as an infinitely large egg. The contents of the egg may be subject to various motions and changes; its parts may pass through countless variations or modifications, but the whole will still be contained in the shell. For whether there be no limit to the diameter of this egg, it is still evident that nothing can pass away from it, and nothing can come to it. This is the universal teaching of science; and as we shall see further on, an absolutely necessary conclusion of the most rigid philosophic considerations. This is the conception we must have of the universe and its various forces. When we select therefore any one branch of study, we must not suppose that such branch is not naturally related to every other branch, or that the thing under consideration has been produced or is governed by any other laws than those which govern the rest of the grand totality. As the universe is one, so are its laws one, all-reaching, and all-governing. With these ideas ruling our thoughts, whether in the study of anthropology where man is the especial object of research, in that of biology where we investigate the origin and action of so-called life-force in general, or in that of cosmology where we consider the origin and evolution of worlds and systems, we shall not be so liable to fall into serious error through unscientific thinking and preconceived ideas. It is frequently necessary to undo ourselves in life, before we can make ourselves anew.

Our universe, mere atom as it is when compared to the grand whole of which it is a part, is humanly speaking a vast city of which our solar system is a single building; and each of the stellar systems composing this universe-city may be called other single buildings of the grand totality whose awful proportions are far beyond our highest imagination, and sufficient to cut off any attempt to express them in thought. Few of the occupants of such a city would ever visit one another. Light requires 129 years to come to us from Sigma Draconis; and this means that it is distant from us 756,625,900,000,000 miles. But to pass from one side to the other of this city (across the galaxy) it is said that light requires 20,000 years. If we should wish to cross it in a passenger train going sixty miles an hour, it would take us two thousand three hundred and thirty million years to do so. It is said by Newcomb that stars of the fourth, fifth, and sixth magnitudes require millions of years to make the circuit of the heavens. Even Sirius, our beautiful and brightest star, is so far removed from us that in a passenger train going 40 miles an hour, we should be twenty-eight thousand five hundred and forty years going to it. Our own sun is about thirty-five million years making a circuit of the heavens, carrying all the planets and their satellites with him. This march of our sun is held to be towards the constellation Hercules. This fact was discovered by Herschel, and has been confirmed by many others since. It takes light more than 48,000 years to reach us from the most remote stars visible through our telescopes.

Many astronomers have labored to fathom the depths, and to acquire an idea of the form or shape of our universe. Among such Herschel stands pre-eminent; but the highest results of all their endeavors are only to give emphasis to the consciousness of man's finiteness, nothingness; and to the absolute futility for the human mind to attempt to comprehend the vastness of such quantities. Yet not only have modern astronomers interested themselves in this question; but even the ancients found no question more worthy of their profound attention.

As we have elsewhere said, in the whole vault of the heavens there are five or six thousand stars visible to the unaided eye; but through the aid of the telescope not less than 100,000,000 are discovered; and although all these belong to the stellar system, so vast are their distances that to us, even through the most powerful telescopes, they appear simply as points.

Dr. Gill, an English astronomer, working in the clear atmosphere of the Cape of Good Hope, has made very elaborate observations of solar parallax; so has Dr. Elkins of this country. Taking into account the work of these men, and the similar labors performed by the ablest astronomers of the foremost nations of the world, it may be said that the nearest of the stars is at an almost inconceivable distance from us. Alpha Centauri, a star in 60° south declination, and therefore invisible in our latitude, is the nearest to our earth; but even its distance is so great as almost to surpass our imagination. Taking for a unit of time the distance that light travels in one year (386,000 multiplied by 365 by 24 by 60 by 60 miles) which is about 237,000,000 times the circumference of the earth, we may say that the distance of Alpha Centauri is four and half units; the distance of 61 Cygni, about seven and half units. About twelve other stars are known to be distant from ten to thirty of such units; most of the other stars are at such great distances that no calculation whatever can be made. It is, however, confidently believed that the star Canopus is not less distant than one hundred light units from us. Its parallax is given as $0''.03$. The parallax of Alpha

Centauri is 0″.75; and its distance as we have stated is about four and half units. A railway car going to this star at the rate of sixty miles an hour, would take 40 million years to reach it. A cannon ball going at the rate of one mile in five seconds, would reach this star in about 3,400,000 years. To reach Canopus it would take twenty-two and half times as long. Even a beam of light takes about a hundred years to come to us from this star.

The size of some of these bodies is immense. If Canopus were brought as near to us as Cygni, it would shine ten-thousand times more brightly than the latter, and a hundred times more brightly than Sirius. The mass of Sirius is nearly fourteen times that of our sun. Indeed, it is well known that our sun is but a star of rather small dimensions; and if it were removed to the distance of the fixed stars, it would but modestly twinkle.

I have used the word parallax. As this is the means of obtaining the distances of the heavenly bodies, it may perhaps need a little explanation. If a person stands on a prairie, and looks at a body some miles away, say to the westward, and then moving northward or southward looks at the body again from the new position, it will appear to have suffered a displacement. The observer's line of sight will not fall on the same objects as before; but when the lines of vision pass the object, they will cross each other, and fall on different objects. This displacement is called parallax; and the distance between the points of observation, the base-line. The base-line used by the astronomer in measuring the distances of nearer bodies is the semidiameter of the earth; but when trying to measure the distances of the stars, he uses no less base-line than the semidiameter of the earth's orbit, which is somewhere about 93 million miles. Notwithstanding the great length of this base-line, it is found that at the fixed stars even this appears as a mere dot, and in some cases is reduced to a mathematical point. We know as we go further and further from objects, they appear to come closer and closer together; but think to what distance we would have to recede, before objects 93 million miles apart would appear to be one and the same. Yet this is just what would happen if we viewed from some of the fixed stars objects separated by 93 million miles.

The vast distances which separate us from the stars, might lead a person unacquainted with physical science to suppose that laws different from what obtain with us, rule in those far-off bodies; but we have no reason for such supposition. Take for instance the law of gravitation: it is found to rule with them as with us. It was long known that Sirius was subject to certain variations; and Peters and Awers came to the conclusion that these variations could be accounted for only on the ground that this mighty star or sun had a satellite. The elements of the suppositious orbit were computed, and from time to time the position such a satellite should occupy in the heavens, was announced. This went on until Mr. Clark of Cambridgeport, Conn., turning the telescope on Sirius one evening, in February, 1862, discovered the companion of this star. Its position was found to be exactly that which had been pointed out by the astronomers mentioned. The mass of this satellite is found to be about one-half that of Sirius itself. The star Procyon is another that exhibits variations thought to be accounted for only on the existence of a companion or satellite forming with the star a common centre of gravity. This satellite has not as yet been discovered; but the fact that it has not been is probably because of its smallness or darkness. Again, according to the laws of Kepler, it appeared that there should be found a planet between Mars and Jupiter. Excepting this gap the order of the planets appeared regular enough. Astronomers felt certain that such a planet might be found; and in 1800 an association of them divided the zodiac into twenty-four parts, thus distributing the work of observation evenly among them. As it sometimes happens however that the unexpected does occur, so in this case: on January 1st, 1801, Piazzi, of Palermo, found a star in the constellation Taurus, which he thought did not belong there; and observing it again the next night, he saw it had changed its position among the stars. For six weeks he traced the path of this star, when it was finally lost in the rays of the sun; he then concluded that it was beyond all doubt a planet. The following autumn every astronomer was full of a desire to behold this planet; but the problem just where to point the telescope was not an easy one to solve; but even here the skill of Gauss was sufficient. He went to work and determined the point in the heavens where the planet should be found, and through him it was again seen before the end of the year. Piazzi called the little planet, Ceres. Another startling proof of the unity of the laws of nature is seen in the discovery of Neptune and his satellite. In 1820 Bouvard of Paris announced the fact that the perturbations of Uranus could not be accounted for on the laws of gravitation; and he prepared tables proving his statement. In 1845 Arago asked his young friend, Leverrier, to search for this planet. In 1843 Mr. Adams of England, then a student of Cambridge University, having learned from Professor Airy of the iregularities of the planet Uranus, set to work to determine the cause. In October, 1845, this young man gave Professor Airy the elements of a planet which he thought would account for the Uraniun perturbations. Airy, however, was somewhat credulous, and failed to take hold of the matter. Shortly afterwards Leverrier completed his elements, and they agreed exactly with those that Mr. Adams had given Professor Airy. September, 1846, Leverrier wrote to Dr. Galle of Berlin, asking him to try to find the planet; he did so and on pointing his telescope soon found the long expected body. Neptune was thus discovered, September 23rd, 1846. Such are the striking proofs of the universal-ity and oneness of the laws that bind together both the heavens and the earth. Neither fate nor chance is found, but everywhere law and harmony, that make the mighty cosmos one.

Again, by means of spectrum analysis we are certain that very many of our earthly elements are existing in the sun and other stars that roll over our heads. "The principles of spectrum analysis," says Roscoe, "are simple enough. When any number of solid or liquid bodies are gradually heated, they will all be seen to become luminous at the same temperature. If the light which these bodies emit when they begin to glow or become luminous, be examined by means of a prism, and suitable optical arrangements, we observe that the rays of least refrangibility, viz., the red rays, are first seen, and that as the temperature rises, light of greater refrangibility is gradually emitted, until at last the bodies give off blue or violet rays. When this point is reached the substance appears to the naked eye to be white hot, as all the differently colored rays, when brought together on to the retinue, produce the effect which we term white light. It is thus clear that the spectrum of every incandescent solid or liquid, is the same, a bright continuous colored band, whose rays extend without a break through all the colors of the rainbow from red to violet." "The case is quite different," says Helmholtz, "if the light is emitted by an ignited gas or by an ignited vapor, that is a substance vaporized by heat. The spectrum of such a body consists, then, of one or more, and sometimes even a great number, of entirely distinct bright lines, whose position and arrangement in the spectrum is characteristic for the substances of which the gas or vapor consists, so that it can be ascertained, by means of spectrum analysis, what is the chemical constitution of the ignited gaseous body." So perfectly does this analysis tell the tale, that the 200,000,000th part of a grain of soda can be detected by its means, or the 6,000,000th part of a grain of lithium, or the 1,000,000th part of a grain of strontium, or the 1,000,000th part of a grain of lime. Thus can the scientist analyze the stars as they in silence pass over us; thus are they forced to reveal their nature and constitution, however much they seek to hide it from the mind of man. Indeed, it is quite probable that by this means the scientist can as easily, and with as much or more certainty, determine the constitution and condition of the stars as if he had them at his hand in the laboratory. By this means calcium, iron, sodium, magnesium, alumina, barytra, hydrogen, mercury, antimony, bismuth, thallium, and many other terrestrial substances have been found in the heavenly bodies. In the spectra of the sun and other stars, there are found lines that can not be identified with any found in the examination of terrestrial substances. It is believed that the reason for this is not that the essences of such substances have never existed in the earth; but rather that the necessary conditions for their modification have not as yet arrived in the stars and sun as on the earth. From what we know of the composition of distant worlds, and from the general laws governing the universe, it is reasonable to believe that every substance we have on earth exists in the other heavenly bodies, either actually or potentially. Whatever earthly elements are not found in them now, will be as soon as the conditions are present which led to their formation in the earth. We have every reason to believe that every satellite revolving around its primary, and every comet that wanders around some distant centre, and every sun that rules his majestic system, is composed of exactly the same original stuff or substance; but that owing to the different conditions prevailing in different stars and other worlds, the same elements can not be found associated in all heavenly bodies at the same time.

From the fact that all the planets known in the time of Kant, namely six planets and nine satellites, move around the glorious centre of our solar system in circular orbits, and in the same direction in which the sun itself revolves on its axis, and very nearly in the same plane, he was led to investigate the origin of the solar system; and in due time became, perhaps more than any other, the author of what is known as the nebular hypothesis, although Kant himself attributes the original idea of this hypothesis to Wright of Durham, England. This theory is now universally received by the scientific world as giving a reasonable explanation of the origin of our solar system. Elsewhere we have given a more full account of it.

We confess that we have often felt strangely restless when thinking of our earth as a ball whirling through space with such frightful velocity; and when recalling the narrow escape of the comet of 1843 from falling into the sun, passing within three or four minutes of its surface, and even directly through not less than 300,000 miles of its corona, I have often pictured the sun as some fiery monster devouring with merciless greed, one by one, every smaller world as they come within reach of his merciless jaws. I have thought of that comet as of an intelligent being filled with the terrible consciousness of the awful destruction that threatened it. As it approached its threatened doom, how terrible must have been the feelings that convulsed its beating heart! But just when the starry spectators expected its utter destruction, it put forth one mighty final effort, and with the speed of 350 miles a second it rushed away just as the fiery monster was opening its jaws to swallow it. What a race for life!

Again, I have imagined myself being on one of the smaller planetoids about twenty miles in diameter, looking, as it were, over its side, down, down, into the awful depths of space, expecting every moment to be hurled into the awful depths below. This is not very scientific, but imagination will sometimes run riot. Even as I think of myself on the earth going with the velocity of nineteen miles a second, I think of the possibility of meeting some stray body, and going up in an instant in the shape of nebula; or of the possibility of some unknown forces causing our mother Earth to leave her orbit, and end her existence by plunging into the embrace of the sun, or into unknown and unfathomable depths of outlying space. If we were thus carried into the sun, however, we should have ceased to exist long before the earth's destruction. The earth would be 64 days 13 hours and 39 minutes falling, or exactly as long as it would take it to make a half of a revolution around the sun in an orbit having a diameter equal to the earth's present mean distance. The planet Uranus would be 5424 days 16 hours and 52 minutes falling to the sun; and the moon would be 4 days 19 hours 54 minutes and 36 seconds falling to the earth.

The standards of weight in astronomy are the sun and the earth; the standard of measurement is generally considered the mean distance of the earth from the sun. If we weigh a bushel of potatoes we act on a precisely similar basis: we simply determine the ratio between the sack of potatoes and the weight of some body with which we are comparing it; and if we wish to know the distance from New York to some outlying town, we find it in terms of chains, miles or leagues. Thus in determining the distance of a heavenly body, we can find it in terms of the earth's distance from the sun. If we know the distance and period of one planet, we can always find the distance of another whose period has been determined; for the square of the times of the planets are proportional to the cubes of their mean distances.

If we fasten a weight to a string, and whirl it around our head sixty times a minute, the string must be twice as strong to whirl it around the same number of times, if its length be doubled; and if the string remain the same length, it will have to be four times as strong, if the velocity be doubled. From this law of centrifugal force, and the law of gravity, we say that gravity varies as the mass divided by the square of its distance; and that gravity varies also as the distance divided by the square of the velocity. This gives us the equation: mass equals the cube of the distance divided by square of period or velocity. Therefore in comparing the mass of the earth with that of the sun we say: The mass of the sun is to the mass of the earth as the cube of the earth's distance from the sun divided by the square of its period is to the cube of the moon's distance from the earth divided by the square of the moon's period. $M : m = \frac{92381000^3}{365.2564^2} : \frac{238820^3}{27.32^2}$. This gives for the sun's mass 328,000 times that of the earth. So in weighing any other heavenly body: we compare the work one does with that done by the other. Thus the astronomer can weigh many of the heavenly bodies perhaps with much more precision than the grocer can exhibit in weighing a pound of sugar or butter.

Thus the whole cosmos is bound together through the common ties of descent and life; and every member, near as well as remote, manifests a close relationship.

A beetle flying into a large ship-building establishment, happens to alight on a decaying piece of wood, where it begins to feed voraciously on the organisms suited to its nature. All its thoughts are centered here; and its highest ambition is to locate such another feeding place for to-morrow. It observes the marks of its own feet and jaws, but recognizes no higher signs of mind. To it the whole establishment is a chaos. It fails to see any order or purpose in the different placement or arrangement of the various materials in all stages of preparation. It sees the human workers busy as itself; but does not connect the various material, the human movement, and every turn of the machinery with the mighty vessel soon to be launched upon the bosom of the great deep. It sees itself as the one thing more worthy than all else, perhaps as " a little below the angels." So the butterfly pays no attention to the characteristics of the flora according to which it is classified. It is wholly employed in raising its kind, fully believing that it is its duty to multiply, and replenish the meadows. The filaria nocturna wandering among the red blood corpuscles of the human organism, sees nothing but a disordered shapeless mass in its surroundings. It is conscious of its own superior worth; and thus it roams proudly along, bent on its own selfish ends, not imagining that it is a disturber of the peace and harmony of the human cosmos. The bacillus diphtheriæ resting motionless is little conscious of the death and ruin that go out from it. It knows itself as something altogether worthy, and thinks it is feeding and breeding in a mindless, soulless universe without form or order. In its own body, the two-millionth of a metre in length, it finds the sum total of excellence. Thus with man: he alights on some little place by accident in this great cosmos; and immediately begins to be busy as the beetle getting food for to-day, and locating some for to-morrow. As the bacillus he is conscious of his own greatness. Indeed, he loves to regard himself in deed and in truth as a "little below the angels." All around him is dead matter, unthinking existences. All things are made for him to gratify his appetite and passions. As the beetle butterfly or bacillus he does not see the unity in all his surroundings; nor the fact that he himself perhaps is an intruder or trespasser, or at most only one of the least important in this great establishment.

I have often thought that the earth would be as much more blessed without man's progeny or kind as the human organism without the multiplying bacteria. How happy must the earth have been having everywhere upon her blessed bosom myriads of variegated flowers and verdant foliage, uncontaminated with the smoke and filth of human toil, and free from human fuss and confusion. Yet perhaps the earth has pleasure in offering man an arena;

although as a gladiator he is not likely to get the laurel wreath on his brow; and even if he wins it, in a few moments it is taken from him, and he is consigned to oblivion forever.

The unity of the universe is everywhere apparent to the eye not centered in self as the beetle's. All are governed by similar laws, all moved by similar impulses, all live in the same eternal life; and all strive, even the atoms, for individual existence. Thus no member of the cosmos is foreign to another. They all have one tongue; and at all times declare, with the most forceful accent, that they are all of one common parentage, and that the hand that made them is the same as supports them, God the everlasting Father.

CHAPTER XVII

"THE EARTH AND THE HEAVEN FLED AWAY" — (Revelation xx. ii.)

MAN being a product of the ever-changing and ever-mysterious forces of nature, and his organism having been subject for such vast periods to nature's destructive no less than to her constructive forces, it would seem that by this time he would naturally regard with equanimity the great and all-embracing changes manifested in the body of nature. But though man's life is but a span, he acts as if it were endless; and thus he can hardly be expected to regard the cosmos as subject to dissolution, although not less than himself it is of necessity doomed to decay and death.

Whether the various existences forming what we call the whole universe, have had as their origin one and the same essence, or many and different, has been a subject of philosophical discussion in all ages; and the ablest minds for not less than four thousand years have consistently held that reason can not possibly admit more than one original essence. Brahminism clearly teaches it; and coming down to about six hundred years B. C., we find very many teaching a similar doctrine: "Οἱ Πυθαγόρειοι τὸ ἓν στοχεῖον καὶ ἀρχήν φασιν εἶναι τῶν ὄντων—The followers of Pythagoras declare the one existence to be the primary substance and cause of all existing things." (Aristotle: Meta. XII. vi. 11.) The mind is unable to think of many eternal existences. To an eternal existence there can be nothing prior, not even the being we call God. It is impossible that there should be many eternals; for such must be the same in substance and attributes, or not the same. If they are the same, then they are not many but one only. If they are not the same, then that by which they differ must be either in being or attributes. If they are the same in being, it is impossible for them to be different in attributes; for the same factors must produce the same results: attributes are nothing in themselves; they are in and of the being or essence of which they are but characteristics. Nor is it possible for two or more existences, having contrary or different attributes, to exist eternally in such harmony and unity as we see in the cosmos. If two or more existences have the same attributes, we affirm they are not many but one; for two or more different existences could not manifest eternally the same attributes; and if not eternally, not at all. We therefore affirm that eternal existence must of necessity be one and one only; and that eternal existences, so-called, manifesting the same attributes, are many in appearances only, in reality being one and the same.

This eternal existence must be infinite and universally present, or else we should be forced to admit space to exist, where there is nothing to give it existence: we can not admit to exist, what has no existence. Where there is substance or existence there must there be space; but space in itself is a negative term; nothing remains nothing, and can not become something. Eternal existence must therefore be omnipresent. It must also be unchangeable, the same yesterday to-day and forever; for to admit that it can change, is to deny its eternal character; for everything changeable is of necessity stamped with finite characteristics.

In this one universal eternal existence has every form that has ever been, had its being; and from it has arisen every force that has anywhere at any time acted. There is no force, no sensation, no consciousness, which does not in truth arise because of it; no force, no sensation, no consciousness which has not always been existing potentially in this one plasma or substance; and this plasma being before all, and generating all, must have in it every possible perfection. In the words of Euripides: "δεῖται γὰρ οὐδενὸς" (Hercul. Furens, 1345); for denying this we should be obliged to postulate another existence superior to it, and we have shown the existence of two eternals to be impossible, and unthinkable.

As a class scientists are moved by the love of truth and truth alone; but we do at times find some even of them speaking loud-sounding words, and making very boastful assertions. It is only a short time ago that an able physicist stated that it would be for the twentieth century to disprove the atomic theory of matter, to show that all forms of energy are from one original, that all atoms are but modifications of one eternal essence, that even what we call ether may yet be shown to be only a derivative form of energy. Now, to a person acquainted with philosophic thought it seems shocking thus to rob and dishonor the great dead, in order to speak boastingly and falsely of the real and possible achievements of the living or of those yet to follow. For more than twenty years the writer has not doubted that every form of substance or energy is only a modification of the One and same eternal and universal Essence or Existence; and it was the study of Aristotle and of the other ancient philosophers that forced him to this conclusion.

Knowledge is a sort of definition, and definition is a circumscription or a delimitation. If we say Vertebrata, we logically delimit or cut off from Animalia a portion called Vertebrata. Whatever is known is therefore a part of a larger and less distinct conception. In this way we know Geometry, Physics, Psychology, etc. Without this larger and indistinct conception of a greater of which the thing to be defined is part, no definite conception of the thing to be defined is possible, and therefore no knowledge of it can be possessed. In this way we know Mathematics from science; Science from knowledge. This last is equivalent to the domain of mental activity; but what this is no one can clearly state. If time should enable us to do so, it would be done only by referring it to some other equally unknown form or sphere of energy; and so on again through eternity. Even if we were in touch with the ultimate Essence, we could not know that we were. For two reasons, and many more might be given, a knowledge of the ultimate Essence is impossible, — first, because it must be general, universal, unlimited, and uncaused, and therefore nothing like the things we know; and secondly, because it is infinitely removed, and something therefore we can never approach. Consequently it can not be for the twentieth century nor for the thousand thousandth century to show that all forms of energy are only modifications or expressions of the One and the Same. It will be for the wisest and best of that century, as for the wisest and best in the centuries gone by, to believe this doctrine; but it must be, for reasons already given, forever beyond the power of finite mind to prove it. But the time will come when no person competent to express an opinion on the subject will doubt its truth. To deny it will be seen to lead to an absurdity. It is a truth of that nature concernwhich Svetaketu speaks in the Upanishads: "Have you ever asked for that instruction by which we hear what cannot be heard, perceive what cannot be perceived, and know what cannot be known?" In this way only are we forced to admit: "All this is That."

Now just as in the destruction of a brick-building we think of the loss of form, and conceive an orderless mass of brick, but do not think of the destruction of the matter out of which the bricks were formed, thus the philosopher regards the many forms of existences which nature has brought forth, as all subject to decay and death, while he regards the one underlying substance or ousia as unchangeable and indestructible.

Man, and indeed every other existence, might well be called a little universe; for from the little we may well infer concerning the great.

The atoms in the animal, plant, or mineral forming the molecular unit, are quite stable, being comparatively near the Original Plasma, although in truth far removed from it; the chemical molecules are less stable; the physiological units are least so. In the building the brick is quite stable, the unit of the structure less so, and the structure itself least stable. In the world systems the analogy holds true. Each system itself is a complicated therefore unstable unit of a body still more unstable because composed of complicated parts. Man's rhythmic existence may be disturbed in many ways. The unit may show the first sign of disease, then the organ. In the system of the world destruction might come first to any member composing it; or disorder and confusion might come first to the system as a whole. Death in either case is inevitable. Death is not, as some imagine, the cessation of activity. The forces at work in death are exactly equivalent to those at work in life. The latter, as it were, winds up, the former unwinds; the latter builds up, the former tears down; but there is nothing of the original force or substance lost.

Whatever system has an origin, must of necessity have an end; for having originated it was not eternal, and not being eternal it could not be endless. Moreover we have shown that only the One Infinite Plasma can be eternal. It is natural, therefore, for all originating forms to change, to die, and therefore for the different world systems, therefore for the solar system, therefore for the earth. But to know all the causes that work destruction or death in world systems, or in any member of them, is another question. Just as in the case of man we have discovered certain causes, and will discover more, that lead to dissolution, so in the case of the world systems or of the solar system, or of the earth, we know certain causes that lead to destruction; but just as in the case of man we know comparatively but few of such causes, and any of these few but very imperfectly, so in the case of the earth or world systems we know but few of the many destructive causes at work, and none of these perfectly.

As man, or finite mind, can never know the original plasma of existence, except inferentially, we being as it were infinitely removed from it; so can the finite mind never solve the complexity of possible causes existing in the units forming the cosmos, nor in the cosmos as a whole. To know this would necessitate the knowledge of each individual cause, the relations existing between them, and the resultant of the whole. To speak of such knowledge as possible to finite mind is most absurd.

As in man many causes tend to destruction, so in the universe many things tend to dissolution; but as in man we are generally confined to probability in speaking of life or death; so in speaking of the many causes apparently leading to cosmic destruction, there is not one of which we can speak with certainty concerning the nature and time of its action. Such causes do not exist apart, and when affected by other unexpected causes the effect that might have been predicted must fail to follow; and it is impossible that man or finite intelligence should ever reach the point where certainty of knowledge of all existing causes can be possessed. Man therefore is a creature of very limited knowledge. His boasted mental power has been little, and must ever remain so. In almost every sphere of thought we see but a repetition of what has been before. One generation cometh up and another passeth away, and the man of to-day differs but little from the man of many thousand years ago. The best of to-day by no means excel the best of five thousand years ago; nor are the worst any more base. The finite mind is necessarily bounded in activity; but when we deal with the life and death of a cosmos, or even of any member of it, we speak of things whose days are as our thousand years, and whose powers compared to our own are almost infinite. All our force, all our skill, all our being is but an atom entering into the life of that mighty fabric we call the cosmos, of which we form a changeful part. In the presence of such vastness we must be humble, and learn to speak with hesitation. But although we are doomed to uncertainty concerning the time and manner of the death of the cosmos, or of any member of it, we may say with certainty that it will die, — that like as it was composed, so must it be decomposed, Birth, life, and death are characteristic of all finite forms. Some may outlive others, but death is stamped on every finite existence.

For many ages atoms were considered the ultimate components of molecules; but today they are held to be composite bodies, and not to differ one from another except in the number of the bodies composing them. These little bodies are called electrons; and all electrons are held to be identical. The hydrogen atom contains 1000 (perhaps 2000) electrons; and any other atom, this number multiplied by the atomic weight of such other atom. The mass of the electron is held to be 1-1000th (perhaps 1-2000th) that of hydrogen. Its rate of motion is said to be 1-12th that of light; and through radioactivity a mass of radium is transformed in about 20,000 years; and one-half of a similar mass of uranium in about 1,000,000,000 years. In this we see what I have long held: the instability of matter.

Notwithstanding all these discoveries, we are no nearer today than in the days of Aristotle to answering the question, What is Being or the plasma from which all things arise? We are fond of using words, especially when they conceal our ignorance. It is so very easy to write "ions," "electrons," "points," etc. Now a point is either something or nothing, but if something it must be substance; also "ion" (meaning going or coming) must be something or nothing, and if something it must be essence or substance; also a thousand electrons must each be something or an activity of something. We say "ion," but what is the ion? We say "point," but what is it? We speak of "electrons," but what are they? It is certain that the solution of one question only leads us to a multiple mystery; and in no case do we get nearer to a definite answer to the question, what is Being or the plasma of the universe. The philosopher knows well that the question is of necessity unanswerable, and must remain so: "*καὶ δὴ καὶ τὸ πάλαι τε καὶ νῦν καὶ ἀεὶ ζητούμενον καὶ ἀεὶ ἀπορούμενον, τίς ἡ οὐσία . . . . διὸ καὶ δῆλον ὅτι τῆς οὐσίας καὶ τοῦ τί ἐστιν οὐκ ἔστιν ἀπόδειξις*—The question has always been asked, and as at present in vain, what is Being. . . . Wherefore, of Being and of what it is, there is no demonstration." (Aristotle: Meta. VI. 1, 7; X. 7, 2.) But it is equally certain that all known existences have been built up out of this one plasma; and that what has been thus constructed, is doomed to destruction, returning again to the more original, if not to the One Substance.

Thus the cosmos must of necessity be dissolved. It is of necessity finite in power, and in duration. The earth, therefore, must die as we; but the manner and time of its death, as in our own case, is a question that can not be answered with certainty. Probability can be stated, certainty never.

Substance being eternal, it is in every way probable that our solar system is only a member of similar systems which in the distant ages gone by have arisen from other existing conditions. As in the churning of butter, the agitation produces many central particles; so in the original condensation many centres of activity arose, which in time formed the various stellar systems, one of which is our own sun with its planets. The different substances or the substance that entered into the formation of the stellar systems, and the resulting systems themselves, must have had definite temperatures; and since agitation, contraction, friction raises temperature, it is in every way scientific to hold that the temperatures of these systems must have been vastly greater than that of the surrounding space; and this must be true of our own solar system. It is sufficiently certain that as time rolls on, the temperature of each system, and of the members composing it, is lowered until finally it must become equal to that of surrounding space. But to answer approximately when such a state will come to our own system, we would have to know the amount of substance in the system, the original temperature, the rate of decrease, the time the system has existed, and its real and possible relations to other similar systems. Whatever answers may be given to these questions, are only guesswork. Yet it is certain enough that death in time must inevitably come to each system, and therefore to ours, from the lack of heat. Heat may come to it from unknown sources, from bodies external or internal to the system; but this would in all probability bring about the death of the system in other ways. Confining ourselves to the sun's mass and temperature, and to its surroundings, it is quite possible to speak with probability of the time when it must fail to give light and heat sufficient to support life; but with certainty science can not speak, for no one can say from what sources or in what manner fresh vigor may come to our central body, upsetting all our calculations. In calculating the limit of our system's existence, different persons will come to far different conclusions; but a few millions of years in the life of the cosmos is not a day in our own, and is not therefore of much import in such considerations. A certain writer has lately asserted that before the end of the present century science will have ascertained the exact time of the world's destruction.

Euripides used to expose to ridicule the pretensions of the priests; but no priest ever made such pretensions as this. If science labored a thousand million years it could never gather the data that could logically and scientifically enable it to deduce with certainty the time of the world's destruction. The problem is impossible with us.

Although we have stated that our sun is in all probability only one of a vast number of similar bodies having a common origin, it is nevertheless equally improbable that their motions are such as may never bring them into collision with one another; or that the motions of other systems, foreign to our stellar system, might not bring these strangers from out of the depths of space across the path of our system, or of any member of it, and thus bring death and destruction.

There are a vast number of worlds that have long ago been laid to rest. Of these we know next to nothing. Yet it must be admitted that any of these might at any time take it in their heads to come to see us, and carry utter destruction in their visit. Nor can it be shown that our solar system is in itself stable; nor could any amount of mathematical calculation make the philosophic mind believe that it is. Just as certainly as a system is born, so certainly must it die. Whatever has an origin, must have an end.

There is no reason why satellites should move in their orbits forever without change. They certainly may recede from or approach their primaries, and thus bring destruction; and so any of the planets may recede from or approach the sun, and thus bring on a slow but certain death. There are very likely various small bodies revolving near the sun at present, some of which every now and then fall into it; and this fate possibly awaits the planet Mercury. The smaller satellite of the planet Mars revolves around the parent body in about seven hours and thirty-nine minutes, and it is not impossible that this planet will soon be buried in the body of its primary.

The discrepancy found between the theoretical and observed accelerations of the moon, has led to many attempts at an explanation; and such is believed to have been found by Adams and others in the action of the moon upon the waters of the earth, causing friction. This results naturally in the retardation of our earth on its axis, and consequently in increasing the length of our day. This continuing, the time must come when the earth will cease its daily rotation.

Nor can it be reasonably held that the earth's axis is permanently fixed. It has possibly changed in the past, and it will possibly change in the future. Such changes carry with them utter devastation. This may explain some of the terrible convulsions of nature which our earth has certainly passed through.

It is quite generally believed, and reasonably so, that many aerolites have originated in an explosion of the parent body; nor is it at all impossible that a similar explosion does not await our earth. Of the forces pent up within we know but little, nor any more how these may be affected by forces acting upon the earth from without. We know little of our own bodies, and much less of the bodies of the solar system. We are too fond of regarding theories as positive knowledge, and a mathematical induction as beyond correction.

If from causes known and unknown bodies fall into central ones, it can not reasonably be denied that our earth may fall into the sun. Such future may certainly await it.

Stars are rather independently moving bodies, seemingly little interested in one another's welfare, not acknowledging any law against slightly trespassing. Hence collision must at times occur, however seldom. This may explain the unusual and sudden brightness with which some stars have been known to blaze forth. Our own sun is a star. What has happened and is happening to other stars, may certainly happen to ours. Such collision would undoubtedly end the life of the solar system.

It can not be reasonably doubted that the form of the earth's orbit may change even more than it now changes, or has changed in the past; nor that the extremes of temperature thus produced might work complete ruin.

As has been said, to speak of permanency as characteristic of the solar system, is poetry, not prose; far better attempt to prove the immaculate conception of Hercules. Its balance of forces is subject to disturbances, and such disturbances may bring chaos. Young very properly says: "One lesson seems to stand very clearly out — that the present system of stars and worlds is not an eternal one. Backward in imagination we reach the beginning of things, and forward an end. If nothing intervenes the sun must at last solidify and become a dark and frigid globe, frozen and lifeless among its lifeless members of planets." I would add that intervention will not be on hand to prevent the final catastrophe. Intervention is possible sometimes, but not always; it may postpone death as with us the physician may sometimes postpone it. But as with us the intervention of the doctor can not finally save us from death's embrace, so nothing can prevent the final end of the members of the cosmos. It is no less clearly written that all worlds shall die than that all flesh must end in dissolution. We must not seek to clothe the finite with the attributes of the infinite.

In briefly summing up the many ways in which the solar system, or earth, or the present arrangement of things, may come to an end, we may say: The sun in its revolution may collide with other suns dead or living, and thus bring destruction; the earth may certainly in time cease to rotate on its axis as the moon has ceased. If such happened, and the sun were as it now is, one of our hemispheres would be solidly frozen, and the other be dessicated. The earth in time may certainly fall into the sun; it certainly may in time come into collision with some other dead or living sun coming across our system from out of the depths of space; it certainly may be hurled out of its present orbit into fiery or frozen regions; it certainly may change the inclination of its axis; it certainly must in time lose all its internal heat, and fail to receive sufficient from the sun to support life; it certainly may acquire an atmosphere, through collision with a comet or otherwise, completely destructive to life; it certainly may get into that condition where there will be no atmosphere at all; it certainly may have its day or year completely altered; it certainly may have seas where now it has continents, and continents where now it has seas.

While such or similar ends await every world, we can not too forcibly state that such changes do not at all affect the well-being, the perfect state, of the universe itself. Every moment in our own organism, or in that of every animal and vegetable in general, worlds are dying; and worthless and detrimental to the system, are carried away by the excretory functions, and cast out of the organism to be rejuvenated in the workshop of nature; and their places are filled by youthful, active, and efficient ones. The body as a whole, however, is not made even aware of these changes. They occur according to the law of animal and vegetable economy; and it is thus that the animal and vegetable, every organ, every tissue, every molecule, every cell is renewed, and kept efficient during its allotted period of existence. So with the divine Universe: the death of a globe-cell, or of a system molecule does not perturb its perfection nor repose; for such is only according to the law of the Universal Being; and it is thus the Universe never grows old, but remains fresh, youthful, fecund forever.

As a child I was subject to dreams and visions, and even in my advancing years I am not yet freed from them. In my vision I was in a great hall whose extent was apparently immeasurable. In it were almost a boundless audience-room, council-chambers, and a high magnificent judgment-seat; and he that sat thereon was ineffably glorious, and like unto no form that I can describe. From his eyes lightnings flashed, and his words were musical thunderings; and every member of the vast throng bent forward, intent on the words and movements of him who sat on the throne, whose face was star-bedecked, and upon whose shoulders stood the pillars of the everlasting universe. Before the judgment-seat I saw arraigned acquaintances of old, and my heart quaked for them. The sun was there, its once glorious face now unveiled. In decrepitude it stood as if struck with the palsy. Neptune, Uranus, and Jupiter stood near as if looking to him for support; but he scarcely recognized their presence. Mars indifferent seemed unconscious of his surroundings, Death seemingly having paralyzed him. Earth was there in a comatose state, and every member of her once prolific body was motionless and dead. Venus shorn of her beauty stood listless gazing out of half-glazed eyes; and Mercury stood with the many minor satellites of the sun scarcely interested in the awful scene. He that sat upon the judgment seat demanded of the prisoners their plea to the indictment of vagrancy, and parasitism in the kingdom of the Universe. The accused spoke not, moved not, seemingly listlessly awaiting their doom. Loud thunderings were heard, and lightnings flashed through the hall; the pillars upon the shoulders of him who sat upon the throne shook, and the Universe seemed to tremble with emotion. Then amidst the thunderings spoke a voice, or as it were many voices in one, saying: "Take, cast these unprofitable servants into the bottomless-pit of eternal life, there to remain; until cured of their infirmities, they shall come forth, and again shine as stars of the first magnitude in the firmament of God." The awful words were no sooner spoken than "the heaven departed as a scroll when it is rolled together"; and the whole vast assembly arose and cried: " All glory and honor and praise and power be unto Thee, who liveth forever and ever; for there shall be a new heaven and a new earth."

CHAPTER XVIII

THE NATURE OF SUBSTANCE

WHAT is substance? This question has been asked by every philosopher ancient and modern; but, perhaps, there never was an age when the answer was more earnestly sought than it is to-day.

By substance is meant the ultimate or underlying principle or real existence back of all phenomena, and from which all phenomena arise: "Μάλιστα γὰρ δοκεῖ εἶναι οὐσία τὸ ὑποκείμενον πρῶτον. τὸ δ' ὑποκείμενόν ἐστι καθ' οὗ τὰ ἄλλα λέγεται, ἐκεῖνο δὲ αὐτὸ μηκέτι κατ' ἄλλου—Substance is that to which all phenomena are referred, but it itself can be referred to nothing. The ultimate substance appears to be real being." (Arist. Met. vi. 3, 1.)

Substance must be of one or more elements. Every element must be eternal; for if it were not eternal, then must it have come from non-existence, or from another element. If it be held to have come from non-existence, then must it be admitted that existence and non-existence are coexistent and equal, which is absurd. It could not have come from another element; for whatever comes from another, must be either the same in kind or different. If it be the same in kind, then is it not another element; if it be different, then that by which it is different must come from non-existence, which is absurd. Therefore the elemental substance is one universal and perfectly homogeneous being. Moreover, to admit more than one eternal element, is to admit more than one absolute cause, which is unthinkable. There can not, therefore, be more than one eternal elemental existence, and this element must be absolute being or ousia. Since we can not conceive of space except as a condition of being or substance, nor of space as limited, it follows that the elemental substance must be eternal, universal, and infinite. There can be no point in space which is not a point of this one common element, which is unlimited in extent and undetermined in character.

We are easily deceived by appearances. Sulphur exists in several states very unlike one another. Water could never be supposed to be a definite mixture of oxygen and hydrogen. The diamond could never be imagined a piece of pure carbon. Here we have the same substances under different conditions appearing as totally different. Under different conditions the same substance may be a gas, a liquid, a solid. The different forms a substance may assume under different conditions are limited only by our limited intelligence to perceive them.

This elemental substance is the arche and apeiron of Anaximander, in which he believed all possibilites exist, and apart from which no other cause can be conceived.

Its Nature:

It is evident that whatever this elemental infinite substance may be, it can not be what we know as matter; for it has energies manifesting themselves on every hand that are not what we call material. On the other hand, it can not be what we call mind or spirit; for we have energies manifesting themselves on every hand that are not what we call mental or spiritual, and whatever is begotten must be like that which begets: "*φανερὸν ὅτι τὸ γεννῶν τοιοῦτον μὲν οἷον τὸ γεννώμενον.*" (Arist. Met. vi. 8, 8.) It is no wonder we hear of discoveries such as that of radium seemingly overthrowing some established laws; but in truth the principle of the conservation of energy has never yet been violated. The truth is that man does not know substance as it really is, but only as it appears to be. He knows it only under changing and unstable conditions, and not under those conditions to which it must ever return, although seemingly away for millions of millions of years. We know substance as we know a man in prison, or a bird in a cage — held in duress, and ever longing for freer action; and the activities manifested when free from duress are so unlike those manifested when in prison that they can not be recognized as coming from the same source.

If this universal, infinite, homogeneous, elemental substance is not mind nor matter, what is it?

Thales (640 B. C.) held that the divine spirit is universally diffused. But if the divine spirit is universally diffused, then must the universal substance be wholly divine spirit and naught else. Anaximander declares that the universal substance is God. (Arist. Phys., i. 4, 2; iii. 4, 9.) Xenophanes (569 B. C.) looking at the whole universe declares that God is the one and only existence. (Arist. Met. i. 5, 12.) Anaximines (528 B. C.) held the universal substance to be boundless and animated; Heraclitus (528 B. C.) taught similarly; Empedocles (500 B. C.) taught the unity of nature, and the gradual evolution of every form; Anaxagoras (500 B. C.) taught the immanence of the Divine Being in all substance; Mellisus (475 B. C.) taught the unity of the universe, and the eternal nature of its substance, holding that it is neither matter nor mind, but simply the common plasma out of which all things are moulded; Diogenes of Apollonia taught the oneness of creation and of substance; John Scotus (805 A. D.) held that God is the substance of all things; and that all created forms must finally return to God as they came from him; Alfgarabi, Avicenna, Avarroes, Amalrich all held that God and the universe are identical; Spinoza (1632) affirms the oneness of nature and its identity with God; Leibnitz (1648) teaches that the substance of the universe is God; Diderot (1713) held that matter is sentient, and that the universe is God; Kant (1724) teaches the probability of the oneness of substance, and the possibility that matter is thinking being; Herbart (1776) held to one common substance; Lammenais (1782) taught that matter is only God realized externally; Schopenhauer believed the universe to be only objective will. Hamilton (1788) says: "When God is said to create, we construe this as meaning that he evolves existence out of himself"; Lotze (1817) regards the Deity as the universal monad, and the elements as spiritual existences; Bain (1818) holds that the arguments for two substances have lost their value; Tyndall (1820), and Huxley (1825) each holds to a common universal substance; Richter (Chemistry 251) says, "The various elements must be aggregation or condensations of the one and same primordial substance."

Summing up the opinions of philosophers and scientists, it would be fittingly expressed in the words of Parmenides: "Being is unbegotten, indestructible, whole, eternally one, immovable and infinite. With it there is no was nor shall be; the whole is forever now, one and continuous."

None of the philosophers mentioned above was wholly wrong; but I like especially the conclusions of Anaximander and Mellisus on the subject: The common and only element of universal existence is the undifferentiated homogeneous plasma in which all possibilites exist, and out of which all forms are moulded.

The question may be asked, how shall we know this substance? We answer, we can no more know this substance than we know the point at which two parallel lines meet, or at which the asymptote becomes tangent to the hyperbola, or the number of straight lines in a circle. We are forced from very necessity, and from the laws of reason to refer to it and it alone certain attributes, and qualities, and energies; but we know it negatively rather than otherwise. If we attempted to follow the parallel lines until they met, we should never arrive at our journey's end; and in like manner, without any doubt, were it possible for us to arrive at the elemental being or plasma of the universe, we could not possibly know it, since all things we know we know by comparison, and the elemental substance is absolute, there being nothing like it with which it might be compared. Everything defined is defined apparently in terms of that with which we are familiar, although the latter may be in truth even more obscure and less known than the thing defined. It follows therefore that the absolute, having nothing greater, and being a part of nothing, can not be defined, and therefore can not be known. If it were arrived at by investigation, or if it were under our gaze, or in our hands, it could never be possible to determine with certainty the truth of any of these. It has therefore ever been, and must ever be, as far as experimental science goes, beyond the reach of investigation; but although thus necessarily unknown, it is not truly unknowable, since we may forever approach without reaching it, as the asymptote the curve. While we must admit that we can never know it, we are equally sure that we may know it better to-morrow than to-day: "*καὶ δῆλον ὅτι τῆς οὐσίας καὶ τοῦ τί ἐστιν οὐκ ἔστιν ἀπόδειξις*—Wherefore of substance and its nature we have no demonstration." (Arist. Met. x. 7, 2.)

This universal eternal infinite plasma, or elemental existence, although true and only being or essence, is not such as we call matter: "*Τὸ δὲ τί ἦν εἶναι οὐκ ἔχει ὕλην τὸ πρῶτον ἐντελέχεια γάρ*—The first or original existence is not matter; it is purely absolute actuality." (Arist. Met. xi. 8, 18.) It is no wonder therefore that some physicists have so insisted on the identity of matter and force, although we can not regard this position as strictly correct; nor is it any wonder why such wonderful exhibition of energy is manifested in radium. Such a substance is removed far away from the common forms of existence toward its true and only origin — the common and infinite plasma, the simple undifferentiated energy, absolute being, or pure actuality.

In determining the character of the universal substance we must be guided by its phenomena, qualities, attributes. As there is but one substance, and it is eternal, universal, and infinite, it necessarily follows that whatever phenomena, qualities, attributes, may manifest themselves in the universe, must be of this one and only substance. Almost everywhere we see the manifestation of what we call mind or intelligence; and equally extensively are seen the manifestations of what we call matter. It follows therefore that the universal and infinite plasma can not be mind nor matter exclusively, but that in it must be all the possibilites of both mind and matter as Anaximander taught. It is potentially mind, and potentially matter; or, better, it is mind or matter as we look at it. If this position is true, and of its truth we have not had a doubt for many years, then every derived so-called element must be both a spiritual and material existence; or, better, must be an existence having both spiritual and material attributes. The atom of oxygen or the substance called radium is most certainly a thinking existence, as is every point in the unbounded infinite plasma; but its thought differs from man's as man's differs from that of the world past and future. In its sphere its thought is perfect; but its sphere being but a point is infinitely little and incomparably small. Man's intelligence is the summation of hundreds of millions of these points of simple energy, manifesting itself, or focalized, especially in the brain. It is no wonder therefore that the atom forever eludes the grasp of man; but were it caught, then would it be known as not an atom but a compound. The further away we get from unstable gross compounds giving especially the phenomena of what we call matter, the nearer we get to the simple plasma of being giving all phenomena especially the so-called spiritual. But simple substance is far removed. The atoms though inexpressibly small, and wonderfully active, are gross existences compared to the plasma from which they have arisen. Nor is it at all probable that the ether is the original substance. In truth it is perhaps no less removed from its original than the atoms are from it. It is evident that it must be absolute being; for otherwise it could not be first. Therefore this infinite plasma, absolute being, while the source of all movement, can not itself be moved; for whatever is moved by another can not be the origin of movement: "Ὁ κινεῖσθαι μὲν δύναται κινήσεως δ᾽ ἀρχὴν οὐκ ἔχει." (Arist. Phys. viii. 5, 10.)

What awful sublimity there is in the thought of an infinite sphere eternal, motionless, bursting, as it were, with formative energy, pregnant with all possibilities. With it there is no time, for time has to do only with the gross and relative; but here all is simple and absolute. It is omniscient omnipotence at peace. "There are two forms of Brahman, time and non-time. That which was before is non-time and has no parts; that which was after (had its beginning) is time and has parts." (Maitrayana-Brahmana-Upanishad.)

But though the universal and infinite plasma can not be moved by another, it can be by itself — not from place to place, but to act. It is in this self-movement that finite forms arise, all of which, whatever their form, state, or condition, must be of the one and same infinite plasma, since there was not, is not, and can not be any other substance out of which to form them. An infinite substance gives no possibilty of the existence of any other substance in an infinite sphere; and the universal and elemental plasma is infinite. All derived forms are therefore of the one common substance, however unlike they may appear owing to their peculiar origin, and changed conditions in time and space. Gold appears unlike potassium; but we may be sure that they are each of the same substance, although it may never be in man's power to release them from the prison in which they are confined, that they may be free to show their common force and origin. Thus of all metals; thus of all derived existences. In general it may be said that it is nature alone that must undo what it has done. As time rolls on in the abyss of eternity, forms are always returning to the common and infinite plasma whence they arose: "Time ripens and dissolves all beings in the great Self." (Maitrayana-Brahmana-Upanishad.) It will be only by accident, and under the rarest circumstances, that any of nature's more elementary structures are razed by man; and it is more than doubtful that this has ever happened, or that it ever can happen. As we have shown, should it ever happen, man can never know it. He would see strange forces, wonderful phenomena; but just what he had discovered, he could not tell.

Some philosophic minds have held that the originating and the originated are one. This is not strictly true. As well might we say that the house and the earth are one; or that the blade of wheat is the same as the soil and atmosphere.

"If men think that by knowledge of Brahman they will know everything, what then did that Brahman know from whence all this sprang? As oil in seeds, as butter in cream, as water in dry river beds, as fire in wood, so is the Self seized within the self, if a man looks for him by truthfulness and penance." (Brihadaranaka-Upanishad; Svetasvatara-Upanishad.) This is true. While the originated form is of the substance of the originator, the former is infinitely little, and therefore comparatively infinitely weak. While it must be said to be of it, it can not be said to be it; while it is a self, it is not and can not be the Self. Creation arises out of the one infinite and universal plasma, but it is not it, any more than vapor rising out of the sea is the sea.

Is the universal and infinite plasma conscious? I do not see how one can deny this. Whatever is in the derived must come from the source of derivation. The universe has brought forth millions of millions of entities each conscious of self, its moment of time and point of space; so is the infinite whole conscious of eternity and infinitude. All past present and future are "now" in this universal consciousness.

Should the universal substance be considered a person? An intelligent being is a person. The infinite plasma or substance of the universe is infinite intelligence, and therefore an infinite person. Creation may be regarded a mirror in which this infinite person beholds himself; nor is it at all unphilosophical to regard creation as the deity objectifying himself. "This is the Brahman without cause, and without effect, without anything inside or outside; the Self is Brahman, omnipresent and omniscient." (Brihadaranyaka-Upanishad.)

Is creation God? Creation arises out of the deity, but it is not God, as the flower is not the root, nor the root the earth, nor the earth the solar system. Creation and every created thing is of necessity of the substance of the deity; but he is infinitely back of it, infinitely more. There are unending creations, appearing and disappearing, arising out of the one infinite substance; but the divine that is thus objectified is infinitely little compared with the divine subject itself, boundless, fathomless, unseen, unfelt, unknowable. God is the sum total of universal energy; he is the Universal Person.

"Beyond the Great there is the Undeveloped; beyond the Undeveloped there is the Person; beyond the Person there is nothing. The Great Self is beyond the intellect." (Katha-Upanishad.)

CHAPTER XIX

ATOMIC AND HUMAN AFFINITIES

IT may be said that all the changes that occur in the so-called material world are the result of chemical affinity; and in like manner that all the changes that occur in so-called higher life, are generally speaking the result of the attraction of the one sex for the other. Not a brick would be made, nor plank sawed, nor mortar mixed, nor shingle cut, not tent pitched, nor wheel turned, nor axle oiled, nor fire built, nor exertion seen, nor hope expressed, were it not for the fact of the mutual longing of the sexes for each other. Some may question this statement, and in disproof refer to the efficient work of celebate priests and monks; but in answer I would reply that such reference is no more disproof of my statement than to adduce the fact that a child born with three legs and three arms would be a disproof of the statement that man is a bibrachial animal. Monstrosities whether celebates or three-legged children are not natural, not according to law; they therefore can not be adduced in disproof of the truth of statements based on natural law. Not only is the statement in regard to the sexes theoretically true, but the evidence is ever before us of its unquestionable truth experimentally. Analyze thoroughly human activities, and you will find that the final cause of all endeavor is the realization of those relations to which the sexual instinct is ever turning. With more poetry and less of truth, we may say that the final cause of human endeavor is the hearthstone, and the little ones for whom its bright beams are radiated. Not only is humanity driven hither and thither in its attempt to realize those relations to which this sexual instinct points; but the statement is true also of animal and vegetable life in general, and even of the elemental parts that enter into the composition of the adult form.

We often hear to-day of family ties severed because of the appearance in the family circle of "affinities"; and although such severance must frequently give pain to the party forsaken, and bring evil to the progeny, if there be such, it nevertheless remains a fact that where freedom of action is permissible such severance is unavoidable. This is paralleled in the case of the atoms. Oxygen has a stronger affinity for hydrogen than for nitrogen. Indeed it seems almost to hate the latter, even though by force of circumstances united with it. We often see this condition manifested in family life. Men and women are driven frequently to marry by the force of circumstances, men because of their passions, women for the sake of having a home. Seldom is the tie, thus formed, willingly preserved unbroken. In general, formed without thought, or for an unworthy end, the tie is snapped asunder, and the parties to it assume their former individual liberty. It can not be denied that as one element has greater attraction for one than for another; so one man or woman may have greater attraction for one person of the opposite sex than for another; nor can it be denied that when this attraction, this natural inclination, is fully satisfied or fully reciprocated, the union is more agreeable and lasting. Artificial rules, legal restraint, may force compliance with undesired conditions, or hold together those unwillingly bound or hating their yoke; but only nature can keep the opposite sexes willingly, gladly, and permanently united. The mutual love of the opposite sexes is rational and proper, as it is also the strongest and most irrepressible of all animal forces. This being true throughout the domain of life, we have here another great proof of the unity of nature.

We have said that all earthly changes and developments are the results of the mutual love of the sexes; but we can with equal certainty affirm that all chemical changes occurring in the world are the result of chemical affinity. In this case we use a word to express atomic attraction that sometimes straying lovers use to express the object of their illicit longings. That the word should be admissible in the one activity and forbidden in the other, is not natural to say the least. If three persons stand side by side, two married and the third single, the fact that two are wedded will not prevent them disregarding their wedlock, if the third party has the natural affinity requisite for separating them, provided that the parties are allowed complete freedom of action. Indeed, I am convinced from my knowledge of men and women, based on very extensive observations, and very wide relations, that were complete liberty of choice allowed in their intercourse one with another, no more than one in ten of those married would choose to continue their former relations rather than select new companions. Think as we may, make what laws we please, we may suppress nature in these matters; but feelings repressed, and eruptive longings we can not altogether hide, however much we would escape censure, or spare the feelings of others. Similar forces to those that thus bring together the opposite sexes are everywhere evident and acting in the so-called material world, and in the judgment of the writer, equally natural and all-conquering. In our conceit and blindness we call the one force "love," and the other force "affinity"; but mere alteration of words can not alter the fact that the two words are the expression of the same force in nature.

Supposing for instance that chemical affinity should be destroyed, let us ask what would be the result. Nature would be dissolved. Cohesion would be overcome, the molecules would separate, atoms would fly asunder to the uttermost bounds of possibility. The universe would be full of repelling forces: all would be governed by hate. All form, boundaries, beauty, order, feelings, touch, sensation; every organism, every form of life, all modes, all consciousness would be destroyed. In like manner let us suppose the mutual attraction of the opposite sexes should fail to operate. All animal and vegetable activity losing its incentive to action, the grass in the meadows would wither, the tree in the forest decay, the flowers of the garden lose their odor, and every delicious fruit and vegetable their gratifying properties; the earth would lose its cattle on a thousand hills, the sea its myriad inhabitants, the hearthstone its bright and cheering fire, and the halls the mirth of childhood. In every earthly assemblage would the tongue of man be mute, the earth would become a graveyard; and even Death, having no more to conquer, would hide its grim vision in eternal and universal oblivion.

If we ask what is love, we can answer only as we answer the question what is chemical affinity. In the former case it is the mutual attraction and longings of the opposite sexes of human adults, which when according to nature bring them and hold them together; in the latter case it is the mutual attraction (and probably longings) of atoms, which being natural unites, and binds them together with the strongest ties known to natural law. Whatever mystery is involved in the one case, is in like manner involved in the other.

The skeptic may say, "But in man and woman there are feeling and consciousness, while in the case of atomic affinity there is neither." I answer, you speak carelessly, unscientifically, without knowledge. How do you know there is no feeling nor consciousness with the atoms? Have you asked them? Have you been able to make yourself one of them in order to study their modes and activities, as sometimes man does, when trying to learn of the habits and manners of obscure and less civilized tribes? Has the atom not the same right to deny that man has either consciousness or feeling, because it has never witnessed its exhibiton? In holding that there is reason and consciousness in the atom, we do not say that human reason or human consciousness is found in it: man has the reason and consciousness of man, the atom the reason and consciousness of itself. The latter being infinitely little, its mental qualities are in like degree small; man being comparatively infinitely large, his mental qualities are in like degree great. But neither mind, nor consciousness, nor feeling is relatively greater in the one than the other. Each is alike endowed with reason, and with every property that has arisen out of the common and universal plasma, from which every personal quality and characteristic must of necessity have been derived. As in every other case so in this: like begets like. In love-matters as in atomic affinity the manifestation of choice is the common activity, or phenomenon; and this same activity is the one common element of all intellectual endeavor, whether infinitely little or infinitely great; whether in the consciousness of an atom, an amœba, or that of a Newton. The difference is one of degree only.

When red mercuric oxide is heated in a test-tube, it disappears, oxygen being liberated, and mercury deposited on the sides of the test-tube. In like manner when intimate friends impose on each other, and take undue advantage of their relations, we find a dissolution of friendship. Again, when mercury is slowly heated in oxygen, we get the compound red mercuric oxide. In like manner when the sexes are exposed to excitation, allurement and blandishments, we have the probability always of "falling in love," and forming a union. In each case third parties are generally useful, sometimes necessary. Hence in society we have card-parties, lawn-parties, church-parties, and entertainments of all kinds for the purpose of bringing the sexes together. So in the formation of chemical compounds, third parties are generally the means through which the chief actors are brought together. If you heat mercuric sulphide with iron filings, the sulphur will unite with the iron, letting the mercury in the lurch; so in like manner if a man or wife be brought into the company of a third party of the opposite sex who has greater attraction than has the wedded mate, the result will be the severance of the bonds of wedlock, and the formation of a new union. This is just what happened in the case of the sulphur. The cause of the severance of the old relations, and the manner through which new were formed, are exactly similar; there was the temptation of a third party, and the more powerful attraction of the new acquaintance.

We all know how unstable newly formed friendship is. It takes but little trial, little hardship, little suffering to sunder such ties. So if potassium iodide be added to a solution of a mercurous salt, mercurous iodide is formed; but the friendship is unstable: on little suffering, exposure, it breaks up into mercury and mercuric iodide, the former going one way and the latter another. So also if you put the heated end of a stick into a test-tube one-fourth filled with concentrated nitric acid, the charcoal will continue to burn, giving a bright light, even though it be beneath the surface of the liquid. This shows how easily the oxygen forsakes its companions, hydrogen and nitrogen, and cleaves to its newly found friend, carbon. Sometimes persons brought together through common suffering are driven asunder when exposed to greater evils. So if barium oxide be heated in a current of air at a temperature above 400°C., it will leave its companion, and take up "single blessedness" again.

In the formation of friendship a person's peculiarities must be observed; so in the formation of atomic compounds: they will only unite in certain ways, and these must always be faithfully observed. They combine in definite ratios or proportions; and under no conditions can they be forced to unite, when these proportions are ignored. Two atoms of hydrogen will unite with one of oxygen, and form water; but three will not: the molecule of water will not suffer the presence of a third party. With humanity the more complicated the friendship, the more easily it is dissolved; so with atomic compounds. Sulphuric acid is a complicated compound. If it be forced to endure much hardship, it will break up. Heat it in alcohol, and we get alcohol water and olefiant gas. The acid has been completely dissolved. We also know that suffering, worry, care, and other evils at times so change one that even his friends fail to recognize him. This is true in the case of atomic compounds, and even with some of the atoms. If carbon dioxide be put under great pressure, at a low temperature, it is converted into a liquid; and none of its friends recognize it in its new form. It is a form it hates; and when left at liberty, begins rapidly to resume its former state.

There are certain persons between whom friendship is almost impossible; yet such are known to become attached to each other, and to combine against a common enemy, or because of common danger. Thus with the atoms. Oxygen seems to hate nitrogen, refusing under ordinary circumstances to have anything to do with it. If however they happen near each other, surrounded by great heat, in the presence of metals (in this instance a common enemy), they will unite, and form cyanides. This comparison might be indefinitely extended, but what has been given will suffice for our present purpose.

The chief barrier that has prevented and does prevent man from seeing himself as others see him, is his inborn egoism — the result of principles inculcated not merely during one short life, or one century, but during many thousands of years. In the Journal of the American Institute of Homeopathy for June, 1909, a certain physician makes the statement that "man is the most wonderful creation of God." As I read his words I feared for his patients; for surely no man with an education such as a physician should have, could make such boastful assertion. In the same journal there were given the names of no less than twenty-five physicians who after stating as their belief: "I declare it to be my most conscientious opinion that if there were not a single physician, or surgeon, or apothecary, man-midwife, or chemist, or druggist, or drug in the world, there would be less mortality among mankind than there is now. We have assisted in multiplying diseases; we have done more, we have increased their mortality." Of persons who can have such opinions, and yet continue to practice medicine, it can not be said that they are the most wonderful creation of God. I do not think that any candid scholar can find in man anything more wonderful than in ten thousand other existences. Indeed, he is much less wonderful than many of the most complex and highly developed plants and flowers; and certainly there are various insects fully as complex and wonderful as man, and many animals far more graceful and beautiful. Nor does man in general give any evidence of a higher origin; for speaking from extensive experience I am sure that the great majority of men live very irrationally. It may certainly be said that only a few do not regret, in the evening of their lives, of having lived as they have. That the most wonderful creation of Infinite Wisdom could thus so completely fail of living a life agreeable to his well-being, can not be believed. The best that can be said of man is, that in speaking of him there is no place for superlative adjectives nor exaggeration. Man is a member of the animal kingdom, and is not free from whatever defects pertain to the offspring of mother Earth. We would not belittle him, nor would we stultify ourself. On the other hand we can not close our eyes to nature's revelations, nor show ourself recreant to the trust she has committed to us. The meanest of substance is holy in God's sight, and every atom of it is a centre of his divine activity and being.

It is hard to see why man can boast of being the greatest creation of God, knowing how far he falls short of living according to reason and natural law. The atom is not found acting in a manner destructive of its own being, nor violating the sacred laws of nature. If its sphere is small, it is most important; if its status is mean, the well-being of all others depends on it. It acts when and how it should, doing fearlessly faithfully and efficiently the work assigned it to do. Its sphere is a point; but into this point is compressed a wonderful force manifesting at all times stability, faithfulness and regularity. It chooses the right thing, in the right manner, at the proper time, in the right place, and in the proper proportion; and this is the power which we affirm to be the highest expression of reason. But as before stated the reason and consciousness of the atom are not that of man, as the zephyr is not the hurricane, as the spray is not the cataract, and as the sound of a gnat is not that of pealing thunder. But man however much more apparently noble or great than the atom, is really of the same material or stuff; and of that material the smallest point is a centre of the Divine Being, and in truth, therefore, a centre of reason and conscious personality.

Could we know the atom as it is rather than as it appears to be, we should behold in it an expression of the Absolute Existence, God unveiling himself, the Unseen making himself evident, the Being unaffected by time and space, circumscribed and delimited, as it were; and all this for the purpose of manifesting himself to the creatures begotten in time out of his Divine Body, in the womb of eternity. Thus the atom is nearer the Divine Existence than is man: man has gone after strange gods; but the atom remains steadfast and true — an infinitely small point through which the One and Only Existence may manifest his Being and attributes.

CHAPTER XX

INFINITESIMAL ARCHITECTS, BUILDERS, AND GUARDIANS

SIR WILLIAM THOMPSON estimates that it would take 5,000,000,000 atoms to extend one inch; and Gaudin estimates the number of atoms in a pin's head as being about 8,000,000,000,000,000,000,000. Loschmidt gives the number of hydrogen atoms in a cubic millimetre as 15,625,000,000,000,000,000. This gives not less than 2,500,000 atoms in one linear millimetre. In considering the origin and manifestation of life, it would be foolish to suppose that a being with the very limited powers of man, could possibly discriminate between the manifestation of so-called dead force and so-called living, when having under consideration objects of such infinitely small proportions. Because therefore man can not see the muscles of an atom contract, or its lips articulating, or watch its organs perform their various functions, there is no reason for affirming that the atom is not a living being. When the thing itself is infinitely beyond the understanding of the greatest mind, it were only madness to suppose that we could know all its attributes and qualities. If I have affirmed, and if I believe that the atom is a thinking conscious being, it is not because I have scientifically demonstrated its intelligence or personality; but because of far higher reasons than those of physical science: I am a thinking conscious being; and whatever is in me, must be in the atom either actually or potentially, it matters not which. We are each made out of the same common universal stuff — the infinite undifferentiated absolute living conscious plasma of the Eternal Universe. Life and consciousness are manifested in man because of his grossness; it is not manifest in the atom for two reasons, first because of man's dullness of perception, next because of the atom's infinitesimal character. If we ascend in the scale of grossness one step from the atom, and come to the molecule, we still have to deal with infinitesimals, unrecognizable and inconceivable quantities. The size of the hydrogen molecule we have given us as about .00000004 of a centimetre in diameter. In both atom and molecule, action, activity, vibration — these are recognized; but to distinguish the various attributes and qualities that are involved in action, when manifested by infinitesimals, requires a power infinitely beyond that possessed by man.

Ascending in the scale of gross being we come from the molecule to the aggregation of molecules — an aggregation twofold in character, the one a restless passing aggregation, the other a restful and more abiding. It is because of the changeful character of the aggregation of the second form, that man in general, who knows only by comparison, ascribes to it alone the attributes and qualities of life; and this more especially because he naturally judges all forms of life to be like his own, fleeting, ephemeral. Aeschylus, Euripides, Sophocles, Horace, Vergil, Milton, Shakespeare, La Place, Newton, Thompson, restless fleeting beings, are dead; but the altar upon which they sacrificed, the instruments with which they penned their thoughts, and the jewels with which they decorated their persons, these have not their days doled out begrudgingly in circuits of the sun. They derive not their being through the mediation of fleeting man nor that of any so-called organic form; but springing out more immediately from the body of the everlasting Zeus, they partake more of his abiding nature and quiescent state. Thus though alive and thinking and conscious, to blind man they reveal not their attributes; nor can they hear dumb mortality, nor deaf mortality hear them. Thus between them and us there is an impassable gulf.

One of the lowest forms of restless passing molecular aggregations is seen in the animal or vegetable cell. The Monon, found among the Protozoa, is such a cell. This organism is simply a living mass of protoplasm having a limiting cell-wall without a nucleus. Haeckel insists that it is neutral, neither animal nor vegetable, being, he thinks, the common starting-point of the two forms of so-called life. Packard regards them as having been the earliest beings to appear on the earth, and to be as low in the order of life as any plant. Thus the lowest vegetable and animal forms gradually merge into each other as the colors of the rainbow. What is vegetable and what is animal is often a hot subject of dispute among naturalists. The truth is that we have no reason whatever for dividing nature into three kingdoms. There is but one kingdom of life in nature; for even those who can not grant life to minerals, can not but admit that a common life is manifested by vegetables and animals; and that therefore these kingdoms should be classed as one. The vegetable and animal trees start alike; each consists of a single cell, as is said above, which is found to be chemically similar. Norton says it is impossible to give a definition for all animals that excludes all vegetables. The life of the animal and plant is one life and one only; and the apparent unit of this life is the cell. The cell modifies itself to suit its different functions. The diameter of this elementary and physiological unit is from 1/3200 to 1/200 of an inch; and it is composed of a limiting cell-wall full of protoplasm generally containing a nucleus.

In the unquestionable vegetable world the lowest organisms are the bacteria. The diameter of the average bacterium is one-millionth of a metre; and its average weight, according to Magelli, is about one ten-millionth of a milligram. Some of these have organs of locomotion, and move very freely, others are motionless; some are disease-producing, or pathologic, others are not. They manifest all the functions of the highest life, eating, digesting, secreting, choosing, working, excreting, and generating. Some generate by fision, others by spore-formation. After the spore is set free it soon loses its shining appearance, and takes on the general characteristics of the parent. It is said that under favorable conditions one bacterium may generate 281,500,000,000 in forty-eight hours. The coccus is the smallest of all bacteria, and the anthrax bacillus the largest. Some bacteria live on living matter, others on so-called dead; some require oxygen, some not; all need moisture. Some stand great extremes of temperature; but most require a temperature somewhere between 10°C. and 40°C. Spores are very hard to destroy, standing a temperature of 150°C. for hours, where there is no moisture.

As with the vegetable cell so with the animal; it eats, digests, secretes, chooses, works, excretes, and generates. Thus the fundamental element of animal and that of vegetable have common characteristics, and a common constitution. With this general introduction, we will proceed with a more thorough examination of the cell.

The protoplasm of every cell ingeniously forms a limiting membrance externally for self-preservation; and, in general, a nucleus internally, whose special work is procreation, and wherein are more especially the factors for the transmission of hereditary characteristics. Every cell accommodates itself to the work to be done, and to the place of action. Cellular variation therefore seems undoubtedly the result of voluntary effort and involuntary environment; as the human laborer adapts himself sometimes voluntarily, and sometimes becomes adapted by force of circumstances. As among men we have peculiar men for peculiar work, so in these most elementary forms of so-called life, we have epithelium-cells, glia-cells, gland-cells, connective-tissue-cells, vessel-wall cells, spermatogenic cells, and various others, and it is a general law that "in every case all germinative tissue is capable of evolving only such tissue-formation as corresponds to the mother tissue, or is closely akin to it." (Ziegler.)

When not subject to pressure the cell is round; when subject to pressure, it takes on such forms as allow it the most freedom, and give it the most efficiency in accomplishing its own proper work. Hence we have flat cells, spindle cells, columnar cells, cylindric cells, fusiform cells, polygonal cells, and others; and they vary in size from 1/3200 of an inch to 1/200.

The life of a red blood-cell is said to last from two to three weeks. When they become old and inefficient, they are seized by certain white blood-cells, officers on duty, and carried to the liver, spleen, lymph-glands, and marrow, where they are reduced to formative material. Out of this whatever can be made use of in the formation of new cells, is carefully preserved; what can not be so used is excreted from the system. Thus in the most elementary forms of life do we behold the manifestation of reason and self-knowledge.

Red blood-cells are non-nuclear, about 1/3200 of an inch long. There are about 5,000,000 red cells in each drop of healthful blood. White blood-cells are nuclear, some having more than one nucleus. On the average there are from two to three white cells to every thousand red cells in healthful blood. The full amount of blood in the human body equals about one-thirteenth of its weight.

The spermatozoon is a spermatogenic cell about 1/450 of an inch long. By means of its vibratory action it reaches the ovum, and enters it through an opening in the vitelline membrane. Arrived at its destination it buries its head in the female pronucleus, and fertilizes it. The two are now truly become one. From first to last the spermatozoon seems guided by intelligence; and in parts of its course even by wisdom.

The term used to denote the transformations which take place in the cell preparatory to cell-procreation is karyokinesis. The nucleus of the cell consists of an outer shell and the inner contents, the latter being made up of two parts, the nuclear substance and the colorless nuclear fluid. In the nuclear substance are found, first, the corpuscles; and secondly, the granulated threads. When dividing, the solid substance of the nucleus, which is called chromatin, or nuclin, increases; then there is formed a lattice-work by the threads running crosswise, forming nuclear segmentation or chromozones. Soon there is formed a wreath-like figure called the mother-star. This star soon begins to alter its shape until there are formed two poles connected by a spindle; and out of these two poles, two stars, one of which is called the daughter-star. Finally two nuclei are seen. As soon as these receive their nuclear covering, the original protoplasmic mass divides near the middle, forming two cells in place of the original one. The nucleus is the special centre of procreative forces, its solid substance more especially being the seat of hereditary characteristics, and the centre of those forces that transmit them.

If any of the great and wise ancients observed the cell in its various stages of procreation; its rapid development; collecting its forces into a wreath or star; sending out its chromozones, forming segmentation; altering the wreath so as to make two poles or wreaths connected by a spindle; perfecting the stars into nuclei, and carefully protecting each with an envelope; finally stretching the spindle-link until it breaks; and out of the two stars forming two complete cells, — they would undoubtedly say that nothing less than an indwelling god could work such transformations, preserving form and characteristics; and I myself would sanction such conclusion. The god I see at work, however, is not one of form, but of reason; and this is the god which the Everlasting Life of the Universe has made of every cell. Thus it acts with reason wisely conserving its forces, and correctly using them. In the face of such marvelously intelligent action, how irrational is it to attempt its explanation by the use of such phrases as "according to natural law," or "through instinct." I affirm that any one who sees in such phrases any satisfactory explanation, is radically lacking intelligence with which to observe anything.

The evidence of self-consciousness also is clear in the case of many of the lowest organisms. The amœba is only a cell, a lump of protoplasm, yet its manner of eating or ingestion is clearly indicative of the power to distinguish self from not-self. Among the white blood-cells the phagocytes also seem to possess this discriminating power. Binet speaking of the Ectocarpus siliculosus, an organism belonging to a group of algæ, a vegetable of the lowest type of existence, insists that they manifest real feeling, and go through all the forms of courtship. Without enlarging on this topic I do not doubt that had man sufficient insight, and the power to examine closely the movements of elementary forms, he would find that these units of being are in possession of both reason and consciousness; nor that if he could lift the veil that hides from his obscure vision the wonders of these infinitesimal worlds, he would see reason and self-consciousness coextensive with existence.

There are many that hold that self-consciousness can be truly predicated of man only. Notwithstanding the difficulty attending any attempt to define consciousness, since trying to define it is not unlike one standing in a tub trying to raise himself by lifting on the handles; nevertheless if we define it as the power to discriminate between self and not-self, or to distinguish *me et meum* from *te et tuum*, such definition will be sufficiently clear to convey a definite and correct idea of what is involved in the word.

A child sees an automobile approaching. Instantly it stands stock-still, and gazes at the coming machine. Neither the premises through which he concludes how to act, nor the final conclusion could be given definite form; but the child acts nevertheless, and acts quickly. His judgment may be false, or the manner of executing it; but the child knows that he himself is not the machine, and that when two bodies collide the impact is inseparable from dreadful consequences. He therefore runs, or turns aside to escape the impending injury. Instead of standing still for a moment, and gazing at the approaching machine, the child by instinct may utter a loud alarm, or scream; and without the least consideration or conscious thought, the child may run anywhere, as in such cases he often does, and the next moment be crushed. There was no failure in either case to distinguish self from not-self; but in the latter case instinct although perfectly correct in the warning it gave of danger, did not choose the right method of safety. Instinct failed here, more especially because man has not only not increased this faculty for many thousands of years, but has even allowed it gradually to weaken, until it is less trustworthy with humanity than in the case of those existences who are more guided by it. Instinct is a rational conclusion drawn from countless millions of experiences, which have been purchased at an enormous price, and faithfully reported with such emphasis and gesture as that the cell, organ, or organization acts unerringly, when similar needs, duties, or dangers arise to those which in the past built up the faculty. Instinct, therefore, is reason most intensified and focalized; and is specially necessary in the case of those beings whose independent reasoning powers are not sufficient to insure accuracy to their individual activities.

Some years ago chemistry was divided into inorganic and organic branches, on the supposition that what is known as the life-principle was somehow a necessary factor in the formation of the organic compounds; but since very many of these compounds have been made, and are now daily making, in all the laboratories of the world, this supposed principle of differentiation has to be given up. To-day organic chemistry is sometimes called, Chemistry of the Carbon Compounds; sometimes, Chemistry of the Hydro-carbons and their Derivatives. By whatever name one may call it, chemists no longer believe that Organic Chemistry is dependent on any so-called life-principle for the formation of its compounds. Especially is this true since potassium cyanide, urea, potassium formate, and acetylene were formed by Wöhler and Berthelot: and since in our own day carbon compounds exactly as they exist in the bodies of plants and animals are prepared hourly with simply chemical means.

Thus therefore the supposed chasm between the so-called living and the so-called dead has been most certainly bridged. The science of chemistry is one science; and its laws are as truly all-reaching, all-embracing in its sphere, as are the laws of astronomy in the greater cosmos. There is one common life, one common reason, one common consciousness, as different in degree as the bodies which these attributes characterize; but in quality and kind one, from the body infinitesimal to God enthroned.

CHAPTER XXI

EVOLUTION OF EARTH'S PROGENY

EARTH'S progeny is generally arranged under three heads—the Mineral Kingdom, the Vegetable Kingdom, and the Animal Kingdom. Of the first we have already said sufficient for a work of this nature. It therefore remains for us to give a brief description of the other two.

THE VEGETABLE KINGDOM

Subkingdom	*Branch*	*Class*	*Order Family*
Phænogams	Exogenous	Angiosperms	Polypetalous: Rose, Magnolia, etc. Monopetalous: Heliotrope, Bigonia, etc. Apetalous: Laurel, Buckwheat, etc.
		Gymnosperms	Cycadaceæ: Cycas revoluta. Coniferæ: Pine, Cypress.
	Endogenous	Spadiceæ: Palm, Pondweed, etc. Petaloideæ: Iris, Amaryllis, etc. Glumaceous: Grass, Rush, etc.	
Cryptogams	Vascular	Heterosporous: Rhizocarpeæ, Selaginellaceæ. Isosporous: Lycopodiaceæ, Filices, Ophioglossaceæ, Equisetaceæ. Fossil.	
	Muscineæ	Musci. Hepaticæ. Fossil.	
	Characeæ:	Characeæ: Fossil.	
	Algæ	Florideæ, Confervoideæ isogamæ, Phænosporeæ, Conjugatæ, Fucaceæ, Confervoideæ heterogamæ, Multinucleatæ, Cœnobieæ, Fossil.	
	Fungi	Phycomycetes: Oomycetes, Zygomycetes. Sporocarpeæ: Ascomycetes, Uredineæ, Basidiomycetes.	
	Mycetozoa:	Myxomycetes, Acrasieæ.	
	Protophyta	Schizophyceæ: Protococcoideæ, Diatomaceæ, Cyanophyceæ. Schizomycetes: Bacteria.	

THE ANIMAL KINGDOM

Subkingdom	*Class*	*Order*
Protozoa	Monera:	Protamœba: Mere speck of Protoplasm (Haeckel's neuter).
	Rhizopoda	Amœba: Cell-wall containing nucleated protoplasm. Foraminifera: Amœba-like bodies, some having shells. Radiolaria: Amœba-like, but have beautiful shells.
	Infusoria	Flagellata, Tentaculifera, Ciliata. The Infusoria have true skin.
	Gregarinida:	Amœba-like, but undergoing metamorphosis.
Porifera	Calcispongiæ. Carneospongiæ.	
Radiata	Coelenterata	Hydrozoa: Hydroidea, Siphonophora, Discophora. Actinozoa: Zoantharia, Alcyonaria. Ctenophora: Eurystomeæ, Saccatæ, Tæniata, Lobatæ.
	Echinodermata	Crinoidea: Brachiata, Blastoidea, Cystidea. Asteroideæ: Ophiuridea, Asteridea. Echinoideæ: Palechinida, Autechinida. Holothuroideæ: Aphoda, Pedata.
Vermes	Platyhelminthes:	Turbellaria, Trematoda, Cestodes.
	Nemathelminthes:	Acanthocephali, Nematodes, Chætognathi.
	Rotatoria:	Albertia, Asplanchna, Hydatina, Brachiona, Rotifera, Floscularia.
	Polyzoa:	Entoprocta, Ectoprocta.
	Brachiopoda:	Shelled worms with two spirally coiled arms.
	Nemertina:	Anopla, Enopla.
	Enteropneusta:	Balanoglossus is the type of this class.
	Gephyrea:	Chætoderma, Phascolosoma, Sipunculus, Bonellia, Echiurus, Phoronis.
	Annulata:	Hirudinea, Annelides.
Molluska	Brachiopoda:	Pleuropygia, Apygia.
	Cephalopoda:	Tetrabranchiata, Dibranchiata.
	Cephalophora:	Scaphophoda, Pteropoda, Gasteropoda, Heteropoda.
	Lammellibranchiata:	Asiphonia, Siphoniata.

- Arthropoda
  - Crustacea: Cirripeds, Entomostracans, Tetradecopods Decapods.
  - Arachnida: Acarina, Pedipalpi, Araneina.
  - Myriopoda: Chilognatha, Chilopoda.
  - Insecta: Neuroptera, Orhtoptera, Hemiptera, Coleoptera, Diptera, Lepidoptera, Hymenoptera, Thysanura, Dermaptera, Platyptera, Odonata, Plectoptera, Thysanoptera, Mecaptera, Trichoptera, Siphonaptera.
  - Malacopoda: One animal — Periaptus.
  - Podostomata: Merostomata, Trilobite.
- Vertebrata
  - Tunicata: Ascidicea, Thaliacea.
  - Leptocardii: Pharyngobranchi.
  - Marsipobranchii: Hyperotetra, Hyperoartia.
  - Pisces: Elasmobranchii: Granoidei, Teleostei.
  - Batrachia: Trachystomata, Proteida, Urodela, Gymnophiona, Stegocephala, Anura.
  - Reptilia: Ophidia, Lacertilia, Chelonia, Crocodilia.
  - Aves: Subclasses — Saururæ, Odontornithes, Ratidæ, Carinatæ.
  - Mammalia: Subclasses — Ornithodelphia, Marsupialia, Monodelphia.
    - Monodelphia: Orders — Edentata, Rodentia, Insectivora, Cheiroptera, Sirenia, Hyracoidea, Toxodontia, Proboscidia, Ungulata, Carnivora, Primates.

Having given a brief outline of the vegetable and animal worlds, it will be proper to speak of their fundamental oneness. As has been said, Haeckel insists that the origin of these two kingdoms is neither vegetable nor animal; and in this he is undoubtedly correct. We will now briefly compare the lowest order of the vegetable kingdom with the lowest of the animal kingdom. The protophyta represent the lowest vegetable; and the protozoa, the lowest animal. The lowest of the protophyta is found in the class Schizomycetes. Here are found the Cocci, the Bacilli, and the Spirilla. Each of these consists of a single protoplasmic cell containing a nucleus. They multiply either by fision or spores. Their food is organic matter; but in addition to this, they must have some mineral. Among these are found the bacteria most pathologic to man, such as the pneumococcus, the typhoid bacillus, the bacillus tuberculosus, and the cholera spirillum. The lowest representatives of the animal kingdom, if such we may call them, are the monera, each consisting of a mere speck of protoplasm, and affirmed by Haeckel to be neither animal nor vegetable. In the branch Rhizopoda we have the amœba vulgaris, the amœba mitis, and the amœba dysenteriæ, parasites pathologic to man; in the branch Infusoria we have, among the Ciliata, the paramæcium, found in the large intestine and fæces, and among the Flagellata, the cereomonus and the tricomonus, the former being found in catarrhal states of the intestine, and the latter in the intestine and vagina; in the branch Gregarinida we have the coccidia, found in pleuritic exudation, and the plasmodium malariæ, found in the blood in malarial conditions. All these three branches representing the lowest animal life consist of individuals each of which is little above the Monon, and consists of a limiting cell-wall full of protoplasm containing a nucleus; and its modes of life and propagation are very similar to those above given of the lowest vegetables. This should be sufficient to show the oneness of the origin and life of the vegetable and the animal kingdoms.

It is certain that very complicated molecules such as are involved in all so-called living forms, can not exist in a very high temperature. Dana thinks that the temperature of the earth at the end of the Archæan period was not above 100°F., and that it must have taken earth many scores of millions of years to cool down to this state. Helmholtz considers that the earth in the beginning of its independent existence had a temperature of 2000°C., and that it took it at least 350,000,000 years to get down to a temperature of 200°C. Much of this is largely guess work, or very uncertain; but it can not be doubted that the earth passed a vast period of time before it was fit for the abode of so-called life. In all probability it had been many millions of years cast off from the central mass, or formed through one of the condensing centres of the parent nebula or cosmic stuff, before it had sufficiently cooled to begin the formation of a solid crust. During the latter part of this Archæic era there is little doubt that conditions were such as to permit of such molecular combinations as are found with the simplest of so-called living forms. Although there is no unquestionable evidence of the existence of any of the protophyta or protozoa during this first age of our earth, it is held that the latter enter largely into the formation of the limestone of that period; for there are millions in each cubic inch of the limestone of the succeeding age. Metamorphism is believed to have destroyed the evidence of their existence. Since the molecular system of so-called living forms is very complex, it is very unstable; and such atomic combinations are generally made impossible where there is great heat. Mineral combinations being more stable compounds find suitable conditions long before so-called living forms. Consequently we have rock-formation probably millions of years before the existence of complicated carbon-compounds. In an organism we have great complexity; and in an organization, complexity multiplied. The complex system of molecules forming organisms such as the Monon or Rhizopoda, is easily destroyed. But an organized being is composed of a vast number of organisms forming a composite unit. This unity is much more easily broken up than the separate organisms are destroyed. It is natural, therefore, that an organism should be evolved long before an organized existence.

The fact that certain forms of these complex molecular combinations appeared early in Earth's history, would lead one to infer that they were capable of overcoming any slight evils which they may have suffered from the disagreeable environments of those days; and such inference is shown to be correct from the fact that many of these organisms are still here as fresh and strong as in Archæan or Silurian days. Bodies that multiply as rapidly as the protozoa or protophyta are as hard to exterminate as their multiplication is easy. If there was not a human typhoid or tubercular patient in Archæan times, in all probability the bacilli of Eberth and Koch were there, although they likely had for hosts less thoughtful and less suffering existences.

I think we are warranted in saying that at some time during Archæan times the following protophyta existed—marine algæ, lichens, and fungi; and of animal life such as rhizopods of the protozoa.

It is apparent to the thoughtful that the first so-called living organism was really not the first, but only one that happened the fittest of very many to overcome the destructive tendencies of their environments; and that as the first so-called life-molecules were many, so out of one or a *few* that survived, would there arise modifications in various directions, altering the offspring of such surviving forms. After many attempts and much destruction there remained two stable shoots from the original stock of so-called life—the vegetable and the animal.

In the Laurentian beds of Archæan times graphite to the amount of about twenty per cent of some layers occurs; and this is considered good evidence that plants and perhaps animals existed. Haeckel holds that monera and amœbæ were abundant in Laurentian times; and that from these rudimentary forms arose zoophyta, or plant-animals, and the first worms. It is probable that whatever forms of plant or animal life existed during the Archæan age, lived in water, and not on land.

During the Archæan age there existed another large, almost formless living organism named Eozoon. LeConte imagines that in this thing may have been the true origin of animal life; he might have added, and of vegetable life. It was in such almost protoplasmic masses that so-called life must have had its starting-point.

Succeeding the Archæan age comes the Silurian, which is divided into the Lower and the Upper Silurian. The

Lower Silurian is divided into three periods, the Primordial or Cambrian, the Canadian, and the Trenton; the Upper Silurian, into four periods, the Niagara, the Salina, the Lower Heldeberg, and the Oriskany.

Through the great disturbances of the earth's crust during this age many species of animals disappeared. There were no fresh-water lakes, and no fresh-water animals or plants; and terrestrial animals were few and insignificant. The great lakes are supposed to have made a beginning at the end of this age, and the continents were well outlined; but mountains were but little as yet above the sea. The limestone formation, once fossiliferous, became crystalline through the great pressure to which it had been subjected in the disturbances of the earth's surface, the pressure acting from the sea landward, slowly but unremittingly for a long time.

Among animal life there were the Protozoa, Radiates, Mollusks, and Arthropoda. All the great species of Radiates were represented; of Arthropoda, the Crustaceans were chief; Vermes were also represented. The sea was full of life; and the waters were warm, making sustenance easy, and the increase of all forms of existence rapid. The great thickness of the limestone of the age proves that life was various and most abundant. Even the arctic regions were undoubtedly mild in those days.

At the beginning of the Silurian the land consisted of the Laurentian of the Archæic age. This forms the shoreline of the early Silurian. It formed Canada and Labrador, and extended northward to an unknown distance. The eastern slope of the Appalachian chain was also formed; in the great sea-basin there were some patches of land where now stand the Rockies, and perhaps very near to the surface in this basin elsewhere. In some places, parts of the great Silurian beach are still discoverable in the primordial sandstones, in the slates of Canada, New York, Pennsylvania, Virginia, and possibly Tennessee, and

Georgia. These rocks are full of shore-markings, sun-cracks, worm-tracks, broken shells, etc.

Through the Silurian age there must have been plentiful vegetation; but plants are easily destroyed, and all signs of their past existence readily effaced through geological changes. It is held that the number of the Silurian species and individuals was not less numerous than today. About 11,000 Silurian species are known; but out of all these not one species is found similar to that of any other geological time. From all existing life that of the Silurian differs in genera, family, and orders. Among plants there were abundant cellular cryptogams — marine algæ. There were also a few ferns and clubmosses. Rhizopods were everywhere abundant. The Radiates were well represented. There were Hydrozoa, Echinoderms, Corals, and Sponges. Of the Arthopoda there were more especially the Crustaceans, which were truly abundant in the Silurian seas. Of the Mullusks there were Bryozoans, Brachiopods, Lamellibranchiates, Heteropods, Pteropods, Gasteropods, and Cephalopods, of which the latter was the most characteristic class; for a subclass of Cephalopods named Orthoceratites was the tyrant of the seas, and reached the enormous length of fifteen feet.

In the Silurian existed also Eurypterids and Pterygoti, huge Crustaceans six or seven feet long and a foot wide or more. There were also worms of various kinds, and a few small and unimportant fishes. During the latter part of the Silurian a few small land-plants and insects appeared: small Blattidæ and Scorpions, and some small ferns and a clubmoss.

The Silurian age was the age of Invertebrates, in number and size never surpassed; and of these, as we have said, the most characteristic were the Mollusks, of which the Brachiopod was especially Palæozoic in extent and time.

We have said that of the Archæan time we have left us scarcely any vestiges of animals or plants except of the very lowest orders; that marine vegetables and animals began to take quiet possession of the earth during the Silurian age, and that at the end of the latter time some few and insignificant terrestrial plants and animals began to appear. We have also stated that Protozoa and Protophyta characterized Archæan times; and Mollusks, especially the Cephalopods, the Silurian; and this is just what we should expect in the evolution of living forms—a proceeding from the simple to the complex. The complex molecule of starch, consisting of 42 atoms, is much more easily broken down than the molecule of water consisting of three; and more evidently is it true that an organized being consisting of a number of related organs each composed of a vast number of complex units, is less stable, has more difficulty in attaining independent existence and maintaining it, than a simple organism such as the Monon, Eozoon or any of the Protozoa. Hence we have it in the history of the earth that all forms appear quite generally in the order of their simplicity. In the age next under discussion therefore we shall have more complicated beings. All this shows the natural order of development. Could the whole tree of Being stand before us untouched by time's devastating forces, it is not to be doubted that with eyes sufficiently microscopic, and understanding sufficiently great, man would behold it complete in every one of its parts, rooted in the one Universal Element, and presenting all the gradations from so-called material to the most highly organized existence. As God can not in the true sense begin anything at any time, knowing and virtually completing all things at once from the eternal past to the eternal future, so therefore must He thus express himself in his Body, Nature, by one eternal universal and orderly manifestation; and therefore creation is not the forming man out of clay nor the Trilobite out of mud, but the gradual development of organized beings from the most simple to the most complex existence.

CHAPTER XXII

EARTH'S PROGENY CONTINUED

DURING the Silurian age the only vegetables were the small vascular Cryptogamous plants and algæ. In the age now under consideration, the Devonian, all orders of vascular Cryptogams—Ferns, Lycopods, and Equisetæ were introduced; and of the Phænogams, Conifera became abundant. There were many species of Fern; there was a gigantic clubmoss, the Lepidodendrid and Sigillarids; Calamites and Asterophillites represented the Equisetæ.

The difference in the seasons must have been somewhat apparent in the Devonian time, as is shown by the ring-structure of the tree trunks, proving times of rest and activity.

In the animal kingdom the chain-coral disappears in this age; the Graptolites so prevalent in Silurian days, pass away forever; the Cystids of the Crinoids have passed away, and the Blastoids increase. Brachiopods are plentiful; the characteristic Orthoceratites of the Cephalopods begin to decrease after Silurian times, in number and importance; but of this subclass the Goniatites first appear in this age. Crustaceans still abound, but the Trilobite begins to decrease. The Eurypterids beginning in the Silurian, hold their ground through the Devonian.

We have stated that few insects existed during the Silurian age; but in the Devonian they were fairly introduced in the order Palæodictyoptera.

Fishes were truly characteristic of the Devonian age; and it is believed that they have never been more numerous nor powerful than in the Devonian waters. They were well equipped to contend for supremacy, and won it; yet there are no Devonian fish in existence to-day. They were Ganoids and Placoids, covered with a thick impenetrable coat of armor. Of Teleosts, true fishes, there was no example.

Of these fish the Dinichthys was 18 feet long and 3 feet thick; the Titanichthys had a head 6 feet across, and was 30 feet in length; the Onychthys was 15 feet long.

The Ganoids as a class must have been fighters; for their thick body-plates, impenetrable coats of mail, made them invulnerable.

The Cephalaspis, the Coccosteus, and the Pterichthys were strange creatures, as if nature's first attempts. The Osteotepis, the Holoptychius, and the Diplachanthus were more like real fish.

The largest and most dreadful of Devonian fish was the Titanichthys. What a fury this monster must have been in the waters! Its sway was world-wide, and there was probably none that did not dread its approach. Even the waters fled before the monster, as into its volcanic mouth fell the unresisting creatures paralyzed with fear. And yet with all their frightful appearance and strength nature has weeded them all out. They were introductory, not genuine fish type; they were as much reptilian and amphibian as they were fish. No true reptile nor amphibian is known to have existed during the Devonian age. For a long time, many thousands of years, probably millions, these powerful Devonian fish held sway, driving before them the rulers of the Silurian age. The Orthoceratites and Trilobites were glad to seek less conspicuous places, and yield up supremacy forever. The sceptre had passed from these representatives of the subkingdoms Mollusks and Crustaceans to that of the Vertebrates, which subkingdom was firmly in power through the class of Devonian fish.

The Devonian deposits are principally shales and sandstone in the Appalachian region, about 15,000 feet thick; while in the West they are principally limestone about 500 feet thick. This limestone formation proves that the great interior basin was in North America a mediterranean sea extending from the gulf of Mexico far away to the Arctic ocean. The lofty mountains of the world had not yet been formed; and therefore rivers must have been small. Where the Rockies now stand there were little islands, reefs here and there, and shallow waters; and the Green Mountains at that time were just lifting up their heads.

The Devonian strata are found in New York, Ohio, Indiana, Michigan, Illinois, Kentucky, Wisconsin, Iowa, Mississippi, and in other parts of the Mississippi basin; but in the main the whole of North America was a great shallow coral-making sea. At the close of the age, however, it is probable that most of Eastern Canada and New England were dry land. More of the Archæan formation was raised above the waters, where it had sunk in the æons gone by; but the amount of dry land in North America was but little compared to what it is to-day. At the close of the period the state of Main and eastern New York rose above the waters.

With the face of the continent so level great rivers could not have existed; though it is probable that the Ottawa, the St. Lawrence, and the Hudson were flowing, and that the Connecticut had its beginning.

Great disturbances and oscillations of the earth's surface occurred at the close of the Devonian age, as is shown from the great irregularity of the deposits—shales and sandstones predominating in the East, and limestone in the West, the former being about 1500 feet thick, the latter about 500. This shows that the great mediterranean sea of Silurian days still gave a quiet home to the limestone forming animals.

The temperature of the different zones differed but little in those days, as is shown from the fact of the occurrence of Devonian species in the arctic regions.

In closing our notice of the Devonian age we may say that it is generally divided into five periods—the Oriskany, the Corniferous, the Hamilton, the Chemung, and the Catskill; but for our purposes we have no need of considering these divisions separately.

What a change had passed over our Mother Earth since she came out of the parent nebula, wrapped in swaddling clothes! Then she was only a fœtus; in the Archæan times, she was a nursling; in Silurian, she was an immature girl; but now she stood a young mother, all her children buoyant with youth and happiness calling her blessed.

THE CARBONIFEROUS AGE

The next age for consideration is the Carboniferous. In Archæan times Protoplasm ruled; in Silurian, Protophyta and Protozoa; in Devonian, Fishes; but in the Carboniferous age the Vegetable Kingdom is supreme. In every age the form that was to rule in the next period, was introduced in the age preceding. During the closing years of the Archæan period the Protophyta and the Protozoa were introduced; during the closing of the Silurian epoch, the mosses and ferns; and at the close of the Devonian, the Lycopodiaceæ, Equisetaceæ, and Filices took possession, and ruled during the Carboniferous times.

In the very dense vapor-laden atmosphere of those days, radiation was greatly impeded, and the earth's surface was like a hot-bed of to-day. Earth was raising forests as farmers fatten pigs—forcing their growth, and fattening them while young, in order more readily to dispose of them. So these forests grew rapidly big and fat on the breasts of the great mother; but not being made of the stuff that stands the tempests and the blasts, they easily fell a prey to furious Boreas; and their bodies found early oblivion in the sepulchre of their own making. I do not say that the earth saw the need of Dreadnaughts or of war-balloons, for that would make her *particeps criminis* before the fact in the murder of her own offspring; but in all probability she knew that her work was to lay up a store of coal and peat that would be at hand in the future for the use of her children, refusing herself to have any responsibility for the right or wrong use of it. So it happens that man has for a long time been supplied with a bountiful supply of coal, which has certainly been no small factor in calling forth his inventive genius, and in giving him the means whereby the highest inventions of the human mind may find scope and place. Were there no coal-beds, it is not at all probable that man would stand to-day the head of the animal kingdom.

The Carboniferous age is divided into three periods—the Sub-carboniferous, the Coal measures, and the Permian. The depth of the coal measures in Lancashire is 16,400 feet; in Nova Scotia, 16,000; and in Pennsylvania, about 900.

In the vegetable kingdom there was great progress, higher and vastly larger plants taking possession of the earth. The very highest Cryptogams were everywhere, and the lowest Phænogams appeared during this age. There were Ferns, the common small kind, and huge tree-ferns, Lepidodendrids, Conifers, Sigellarids, and Calamites. The Sigellarids and the Calamites had a pith in the centre; the former also a hard rind. This rind and pith gave it therefore in a measure the nature of the Exogens. They were at least a connecting link between the Cryptogams and the Phænogams. The Calamites were about 30 feet high, and from 2 to 3 feet thick; the Lepidodendron was a gigantic clubmoss 40 to 60 feet high, and from 2 to 4 thick; the Sigellarids were about 100 feet high, and mav be regarded as partaking of the nature of the Exogenous plants of a later age. The Conifers bore their fruit in a single cone at the top; but they were not true cone-bearing plants; but a connecting link between the vascular Cryptogams and the Cycads. The most abundant coal-plant is the Fern; indeed, it is said to form one-third of the whole number found in the coal-beds. Some botanists see in them a connecting link between the Monocotyls and the Dicotyls. Not regarding various small plants it may be stated that the bulk of the coal was formed by the Ferns, Lepidodendrids, Sigellarids, and Calamites.

During the Carboniferous age there was a great limestone formation. Iron-ore and Petroleum were also productions of those days. Organic matter is considered a necessary element in the formation of iron-ore. With reference to the formation of coal-oil and bitumen, LeConte says: "Coal is formed from terrestrial vascular plants in the presence of fresh water; while bitumen and coal-oil are formed from more perishable cellular plants and animals in the presence of salt water." Mendeljeff thinks that coal-oil had a mineral origin.

In those days the Corals continued as before; Cystids disappear; Blastoids and Crinoids increase; Asteroids continued; and Echinoids appeared for the first time. There were Brachiopods, Lamellibranchiates, Gasteropods, and Cephalopods; of the last order the Orthoceratites appear now in decreasing numbers. The Goniatites were fast losing ground in the race for life; and the Trilobites and Eurypterids continue on the decline.

During this age Insects appear for the first time in Earth's history in any size and numbers. There were Neuroptera and Orthoptera; but none of the highest orders were yet in existence, such as Hymenoptera, Lepidoptera, and Diptera. There were dragon-flies, spiders, scorpions, grasshoppers, cockroaches, and centipeds. There were no bees, nor ants, nor flies.

Of the Vertebrates the great Ganoids and Placoids continue, and still are monarchs of the deep. There were immense Sauroids, true connecting links between Fish and Reptile. It was in this age that reptiles first appear; but they were only an introductory kind. To find the perfect Reptile we have to wait for the succeeding age. During this age we have Amphibians everywhere; they were truly characteristic of this period. As nearly all of Nature's first attempts they were monstrous in size and form. They were what is known as Labyrinthodonts such as the Baphetes, the Anthrocosaurus, and the Zygosaurus. There were the Sauropus, the Denrerpeton, the Hylerpeton, the Archegosaurus, the Raniceps, the Hylonomus, the Ophiderpeton, the Apeteton, the Eosaurus, and the Amphibamus. These Amphibians had large armor plates, invulnerable coats of mail, and great scales under the hinder parts of the body.

The fact that there was limestone formed during the Carboniferous era shows that the earth sank beneath the waters during this time; and remained there for ages, where limestone-forming animals lived, worked, and died, giving their bodies to build the strata of the earth. It is by such oscillations that the different rock-layers have been formed, some in deep waters, some in comparatively shallow, some by shore or beach-action, some by deposit of sediment, some by vegetable stratification.

The duration of the Carboniferous period, like that of all others, is quite uncertain. That the time was vast, there can be no question; but to the question, how long, different authorities will give different answers. It was probably from two to three million years.

We have now briefly glanced at the earth's condition and development during two great æons, the Archæan and the Palæozoic time. Without much doubt the Archæan was vastly longer than all succeeding times; so it may probably be said of all the other ages that each was longer than all subsequent time thereafter. The Archæan age was probably a hundred million years long; but as has been before said some geologists affirm that the earth is thousands of millions of years old, and Dana does not appear to be greatly surprised at their statements.

Wonderful was the change that had passed over the earth since she had come forth from her mother the cosmic nebula, trembling, uncertain, anxious, forced to stand alone among the galaxies of heaven. She certainly had no reason for shame as she stood a goddess as beautiful as noble, in her mantle of emerald and gold, patterned as beautifully as the highest art of a god could make it. But she appeared not happy as she beheld the bright beams of Aurora, flashing from the east, heralding the approach of the fleet horses of the king of day. Turning from the golden splendor, and looking into the deep darkness of future eternity, her piercing eye saw the seas already stained with blood, the stagnant forests quivering under the attacks of battling monsters, and the dense clouds of heaven trying to hide from her gaze the fierce combats even among aerial tribes; and she saw in the distance the myriad forms of her own prolific womb destroying one another, and bathing her in the blood of her own offspring. With her beautiful head bent on her breast, and her eyes bedewed with crystalline tears, she uttered such a groan as the gods before had never heard, and as shook the strong pillars of Jove's great temple. Seeing his beautiful daughter thus afflicted, he asked what troubled her heart. In answer she pointed to the ceaseless, causeless, merciless slaughter of bird and beast by man, and of men by one another. The Father's great heart was moved. Bending low, he kissed her brow; but for answer gave he naught, save a nod.

Then said Earth: "Must it ever be thus with the father of gods and men? Shall thy secrets deep lie thus ever buried within thy mighty breast!"

Conscious that none of the gods ever disputes with the One Universal Source of Being, with a majestic movement, and perfect obedience, Earth took up her great work, and plunged into the Mesozoic æon, all the gods in Ouranus acclaiming her act.

THE MESOZOIC AGE

The Mesozoic Age is divided into three periods—the Triassic, the Jurassic, and the Cretaceous.

During the Mesozoic age Mollusks decreased in numbers, and degenerated in character. Even the Terebratulæ, a species specially developed at that time, were inferior to some Mollusks of the preceding age. Brachiopods saw their highest development in Paleozoic times. Gasteropods seem to have been somewhat in the ascending grade in the Mesozoic era; and Cephalopods reached their highest development then. It is doubtful if any Cuttlefish of our own days is superior to the Jurassic Cephalopods. It is certain therefore that during the Mesozoic times Mollusks began to degenerate in kind and numbers; although a few may have continued to hold their own; and this is especially true of the Gasteropods and the Cephalopods, which even in our own late day may not have attained their highest development.

Among Arthropods there were Shrimps, Lobsters, Crabs, and Insects. Of the last there were even its highest representative—the Hymenopters. Among Vertebrata there were Ganoids, and Salachians; and it was during this time that true fish, the teleosts, appeared. During the Mesozoic the Ganoids saw their culmination; but they were seen to be changing: some had vertebrated tails, others not; and ever since that day they have been on the downgrade, in our own time being nearly extinct.

Amphibians, especially the Labyrinthodonts, became gigantic during this age. The scale-covered kind began to disappear after the Triassic period. In our own day we have of such creatures only the frog and salamander with naked skin.

All the great divisions of Reptiles were in existence in the Mesozoic times, and saw then their highest development. There were Enaliosaurs, Ichthyosaurs, Pleosaurs, Lacertians, and Crocodiles. The Reptile world was in the sea, air, and on the land, both grazing and carnivorous kinds; but nearly every Mesozoic genus became extinct at the close of the age. The Reptile expanded even to flying forms, as in the case of the Pterosaurs. Some of these Saurians were frightful and terrible monsters. The vertebra of the neck of the Apatosaurus were four feet broad. The most remarkable of the Dinosaurs was the Triceratops with two horns each three feet long and ten inches in diameter on the frontal bone, and another on the nose. Its head was eight feet long. Another of these peculiar monsters was the Diclonius. It was 38 feet long, had a head three and a half feet wide, a peculiar spoon-like bill, 2000 teeth, and wonderful to say, it was a biped. The Atlantosaur was 100 feet long. Some of these monsters had the feet of birds, others of reptiles. The Laosaurus was strikingly like a bird. These flying Reptiles were the connecting link between Birds and Reptiles; and Amphibians between Fish and Reptiles.

As to plants, Protophyta were everywhere. Sigellarids and Lepidodendrids died out. There were higher plants coming into existence, the Cycads. There were also Conifers, Ferns, Angiosperms, and Palms.

In speaking of the Reptiles of the Mesozoic, Dana says that in the dominions of Great Britain alone there were four or five species of Dinosaurs from 20 to 50 feet long; ten or twelve Crocodilians, Lacertians, and Enaliosaurs 10 to 60 feet long; and Pterodactyls and Turtles in abundance. Since man appeared, he says, there has not been a single large reptile in Great Britain. This shows how fully Reptiles culminated during the Mesozoic age.

North America at this time became principally dry land. In Eastern America there is little limestone; and in Western there is less of this formation in the interior than of fragmental rock. Much coral was formed during this age.

The Mesozoic was closed with great disturbance. The earth arched; and there appeared plains and plateaux where had stood the great interior sea. Thus the continent became one. The Wasatch and Uintah mountains were formed, and the eastern Rockies were begun.

CHAPTER XXIII

THE CENOZOIC AGE

THE Cenozoic age is divided into two sub-ages — the Tertiary and the Quaternary. The Tertiary age is divided into three periods — the Eocene, the Miocene, and the Pliocene; and the Quaternary age is divided into three periods, the Glacial, the Champlain, and the Terrace.

The rocks formed during the Tertiary age are of marine and fresh-water deposits. It was a time during which the earth was engaged finishing and beautifying her former work. There was also some addition to the land-surface by driving back the sea and by general deposits, making the amount of land-surface about equal to the present. During this age many mountains were formed or completed —the Alps, the Pyrenees, the Apennines, the Himalayas, the Andes, and the Rockies. In North America the land was greatly increased along the Atlantic and Gulf coasts. From New Jersey southward a strip about 100 miles in width was added to the land-border. Great additions were made west of the Mississippi; and there was some land-elevation on the east and south. In the interior there were vast fresh-water deposits. It was during this time that the Green River basin was formed; also the Uintah basin, the White River basin, the John Day basin of Oregon, and the Niobrara basin. The deposits were sand and clay, some of which have been metamorphosed into very hard rock hardly to be distinguished from those of the Mesozoic æon. Some coal was formed; but it is generally in the form of lignite.

Little of the Rocky Mountains was formed before the Tertiary age. During this time they were elevated from 6000 to 11,000 feet; and the Pacific border rose at least 3000 feet. Dana says that the amount of earth above sea-level was increased two or three fold during the Tertiary age.

During the Quaternary age the earth continued finishing her previous work: valleys were formed, mountains shaped, earth and gravel removed from one part to another to make the surface more even, prairies formed, and alluvium deposited.

There were great oscillations of the earth. Much of Europe sank below the sea; and not a little of Britain sank from 500 to 1500 feet, and still remains submerged. The great river systems were perfected during the Quaternary age: the Amazon, the Mississippi, the Ganges, the Indus, the Nile, etc. Glaciers were formed through the great mountain-elevation into heights of eternal snow; and the earth probably for the first time had frigid zones. Great rivers ran, mighty icebergs roamed the waters, and the glaciers were finishing the leveling of the earth's surface.

The glacial drift extends over all the northern part of North America, covering the Archæan, the Mesozoic and the Tertiary strata with from thirty to three hundred feet of deposits, made up of sand, gravel, pebbles, stones, and bowlders, some of the latter being from thirty to forty feet every way, and weighing many thousands of tons. They are absolutely foreign to the site where they are found. Those found in New England have been brought from the northwest, those in Ohio from the north, and those in Iowa from the northeast. This shows that they have been transported from the Archæan of the highlands of Canada. In many cases they have been carried across deep valleys, and lodged upon high mountain-tops. The distance to which they were transported was from a few miles to several hundred.

The glaciers of Glacial times were not unlike the Greenland glaciers of to-day, where the whole country, 1200 miles long and 500 miles wide, is covered with ice from 3000 to 6000 feet thick, which is really one massive glacier moving seaward. In the antarctic the glacial surface is even more extensive.

During the Glacial epoch the northern portion of the North American continent was raised as much as 1000 to 2000 feet above its present level; and the ice-sheet extended to 40° north latitude. At the end of this epoch this elevated portion fell again to from 500 to 1000 feet below its present level. Northern Europe was elevated about 1200 feet, and all covered with ice. Britain was then one with the continent. After this, as in the case of America, Europe began to sink, until it is believed Scotland was at least 2000 feet below its present level. Then as in America there followed a period of elevation during which Britain was again united to the continent of Europe. Finally there came another period of depression during which the land became much as it is to-day.

The causes of the Glacial epoch must have been the precession of the equinoxes, and the secular change in the earth's eccentricity. Through the precession of the equinoxes, winter which occurs now in earth's perihelion, in 10,500 years will occur when the earth is in aphelion. If winter occurred at aphelion when the earth's orbit at the same time had attained its maximum eccentricity, winter cold would have been most intense, and summer heat very great: the winters would be twenty-two days longer, and 20° colder; and the summers would be as much longer and hotter. If this be the true explanation of the Glacial epoch, then it must occur again, bringing upon us similar changes to those of the past, and similar destruction. According to Croll the Glacial epoch began about 240,000 years ago, and lasted about 160,000 years.

It is probable that every great change in Earth's surface was made necessary because it had become incapable of maintaining any longer the progeny it had brought forth; and perhaps, also, for the sake of introducing a higher grade of existence.

We sometimes imagine that the era of great changes has passed; that the earth to-day is in a stable condition, and will remain so. This is not really true. The coast of New Jersey is sinking at the rate of about two feet a century; and there are just as great changes occurring elsewhere. The earth we know is to-day leveling up; and the time must soon come when there will remain nothing to level: when all the highlands will have been transported to lower parts, until there will remain no highlands to be eroded and removed. The rivers will then cease to flow; and the inland lakes will be dried up or drained, the sources of their supply having been destroyed. A few years, or a few hundred years, bring little change to the earth; but her life is not counted in years, but in æons; and the time is surely coming when the present order of civilization and life must come to an end, because of the inability of the earth, as in the past, to maintain the progeny it shall have brought forth. The earth seems to work according to her present needs, and sometimes with a view to the future.

It is wonderful to see the gradual development of the tree of life from the Eozoon; wonderful to see Protozoa passing into Fish; Fish into Amphibians of various kinds, some flesh-eating, others herb-eating; to see Amphibians changing in two directions—land-vertebrates, and air-vertebrates; to see the indefinite, uncertain forms becoming more definite in each direction, dropping those peculiarities that made them general, and assuming those that made them special, some finally becoming true Reptiles, others true Birds.

It is not true that all life progresses at all times and everywhere from a lower to a higher kind. Mollusks have never been so high in type nor broad in dominion as during the Carboniferous and Mesozoic eras; nor have reptiles been so high in development nor broad in dominion as during the Reptilian age. It is true, however, that life in general has progressed unceasingly from the more simple to the more complex; from the forms ruling posteriorly or through posterior development, to the forms ruling anteriorly or through anterior development. This law holds good, we believe, from the lowest Silurian life to the highest of the present age—from the Rhizopods to the Primates; and of the Primates, from the Simians to Man.

In every age has been introduced the form of life that was to rule in the succeeding. In the Silurian insects were introduced, in the Devonian they were more plentiful; in the Devonian Fishes were introduced, and became abundant, increasing in kind and dominion during the Carboniferous age; in the Carboniferous age Reptiles were introduced, and became all-powerful in size and dominion during the Reptilian age; and in the Reptilian age Mammals were introduced, and have continued in power and sway even to the present day.

The remains of mammals have been found in the Upper Triassic, as well as in the Cretaceous, period of the Mesozoic age. In South Africa the Tritolydon longævus was found in the Triassic strata. It was a Marsupial, and as large as a gray fox. The remains of a great many species of mammals have been discovered in the Oolithic division of the Jurassic period. In the American Jurassic a great many species have been unearthed, all of which are probably Marsupial mammals. Marsh considers them generalized forms.

Without any doubt the transition from these generalized Marsupials—the lowest of the Mammalians—to the perfect Mammal, has been gradual. If any connecting link is missing, it is not because such connecting link has not existed; but knowing what we do of the Earth's progeny, we should say that probably these missing links, if missing they are, have been destroyed because of the vicissitudes to which they have been subjected. Indeed, it is wonderful that Earth's fauna and flora are as perfect as they are.

At the opening of the Cenozoic age the remains of abundant Mammals are found—Insectivora, Rodents, Carnivora, and Pachyderms; even the remains of an opossum have been discovered in the Tertiary period. As with other classes of life so with Mammals, the first were generalized forms. The Coryphodon had the characteristics of the three orders—the Carnivora, the Rodentia, and the Ungulata. Other quite general forms were the Phenacodus, and the Mesonyx. In the Tertiary period elephantine mammals existed—the Brontotherium, the Dinotherium, the Sivatherium, and the Bramatherium. The progenitor of the horse has been discovered in the early Pliocene. It was then about the size of a fox, and had four toes before and three behind. The horse can be traced through all its changes from the early to the late Pliocene—from its insignificant beginning to its present magnificent state.

In speaking of the future Winchell says that the time must come when the bottom of the Niagara gorge will reach the bottom of Lake Erie, and that then this lake will be drained, only a river remaining where once ships of commerce so proudly sailed. A concomitant result will be the draining of Lake Huron and Lake Michigan, leaving only two small lakes connected by a river "which will flow along the drained basin of Lake Erie, and down the steep unnavigable slope, continuing through the gorge to Lake Ontario."

It has been estimated that the land surface of North America is lowered through denudation not less than three inches in one thousand years. As this is certain, so is it equally certain that this detritus is carried seaward, and that the sea-bottom because of this must be rising gradually to land-level. This must cause the sea to over-flow the land eventually, if the supply of water continues as it is to-day. Again, the gradual cooling of the earth increases the porosity of its crust, and therefore its capacity for water. Many physicists hold that the entire waters of the oceans and all our atmosphere must some time in the distant future be entirely absorbed by the earth's crust. Thus the earth may like the moon roll on in space without water or atmosphere; but as nothing ever happens to man not common to humanity, so nothing can ever happen to the earth not common to such cosmic existences.

Of Fishes the three great orders existed in Tertiary times, the Ganoids, the Placoids, and the Teleosts; and from that time to the present Teleosts rise in power and dominion, while Ganoids have almost totally disappeared, and Placoids hold a very inferior position.

In Cretaceous times Birds were reptilian; but in the Tertiary age true birds of all kinds appear on land and water. Some birds however still retained their generalized type, such as the Odontopteryx and the Gastornis, the latter being ten feet high.

Of Mammals Le Conte says that they keep their Mesozoic type even to the very borders of the Tertiary period, when suddenly the higher type, the Eutheria, appears. He supposes that this type must have migrated into America from some other country, as we do not find all the connecting links.

All the genera of present-day plants existed in the Tertiary period; but of course not in the same localities, for it was much warmer then than now, and all Europe was covered with evergreens such as now are found only in the southernmost portions. The cypress of Carolina swamps existed then in Greenland, where Heer thinks the temperature was 30° above the present-day temperature of that country.

Until comparatively recent times it has been quite generally held that man is not, as are other animals, a natural development; but since such investigators as Darwin, Huxley, Gegenbaur, Haeckel, and many others have given their profound attention to this subject, the world of science to-day does not regard man as having been originally the work of special creation, nor his status in the living world as the result of any special intervention on the part of Deity. Whatever man is or whatever he may be, he is a natural product of natural forces which from the dawn of the first so-called life, have been and are inherent in every living form, regulating, modifying, adjusting, and adapting it to changed conditions, without fear or favor preserving those forms that have shown or show the capacity for such adaptation, and ruthlessly permitting those not thus capacitated to pass away in the struggle for existence.

Knowing the great vicissitudes through which living forms have had to pass, the great oscillations of the earth's crust, the awful cataclysms of geology, and other changes affecting the earth in her cosmic relations, one wonders that scientific men have been able to restore so much of the blasted tree of life; for certain it is that there is scarcely a twig, much less a limb lacking to complete its symmetry and beauty.

Man is a member of the animal kingdom, of the subkingdom Vertebrata, of the branch Mammalia, of the class Monodelphia, of the order Primates, of the suborder Anthropidæ, and of the genus Homo; and there is no more scientific reason for postulating special causes for his origin or development than for that of any other animal or vegetable. The Cenozoic age during which there has been special development of mind, is as truly a natural result of a natural process as has been any other age in the life of the earth. What man has been doing the last few thousands of years, we know something about; what many other animals have done during their development, we know practically nothing about. We can not well enter the domain of the mind of a Chinese or Hindu, much less that of the butterfly or the ant; nor can we judge at all satisfactorily of the skill they manifest in their own sphere for the betterment of their own condition, and elevation of their own kind; nor can we judge their thoughts concerning us and our kind. There is no reason whatever for supposing that there is anything whatever in man different in its nature from what is found in every other animal. It is true that man apparently possesses more brain power than any beast of the field; but it is equally true that this does not take man out of the general laws under which the animal and vegetable worlds have been formed and developed, from the first nucleus of condensation in the world-nebula to the highest exhibition of mental power. Man's conceit, however, will hardly permit him to acknowledge an origin in common with all other living forms. God he imagines must be specially mindful of him for whom, he insists, all other things have been created; of him who if he and all his kind were to disappear from the face of the earth, and from the universe itself, would not leave behind a friend to mourn him except perhaps some over-faithful dog. Nature has not produced a more self-seeking animal than man. He is driven headlong by his passions, his lusts, his selfish desires; and under these forces he is totally forgetful of the rights of others, and careless of, or indifferent to, the woes he creates through his own selfish acts. It is better not to claim too much for man; his actions will not bear very close investigation. Yet so conceited is he that no matter how much he tramples on the rights of others, he imagines God will freely forgive him, provided he is sorry for the evil he may have done. Whether man be considered as living in town or hamlet, city or state, as one of a partnership, corporation, state, or nation, he is ever seeking himself directly or indirectly: it is his farm, his town, his state, his country. The thought that some other farm, town, city, state, or country may suffer through his act, deters him not: he seeks himself always and ever. As some flowers may be forced against their natural bent, so some men may force themselves to be merciful, kind, generous, forgiving, considerate, world-wide in their thoughts; and with some such men the world has always been and is blessed. Such gods however are few. It is time that we should cease to class man with the angels. Let us call him what he is—an animal evolved out of Universal Being under the same laws which have ruled in the evolution of the animal and vegetable worlds. What can be more beautiful than the rose, more symmetrical than the hound or the horse, more skilful than the ant or bee? Verily, forces that produce these natural wonders, need no assistance in producing man.

Nor would we censure man too severely: if he is a very selfish animal, perhaps this was the surest way Nature could devise to make him work and strive early and late to overcome opposition, and to be first in the race for supremacy—first in the farm, first in the village, first in riches, first in power. Nevertheless, if this force were not bridled by laws and customs devised by the better and nobler nature of the few, man's tyranny would be everywhere, and civilization would be impossible. Indeed, man would eventually become extinct from this if from no other cause: grasping selfishness does not, can not elevate; on the contrary it degrades, and destroys.

Some have held that Man is the only two-handed animal; but we are forced to admit that the Ape is also two-handed. If it uses its foot or hind-hand more dexterously than we, so does the Chinese boatman who rows with the foot, and the Bengalese who weaves with it. In the case of the Gorilla the use of the hand and foot is much the same as with Man.

The order of Primates is divided by Huxley into three

Sub-orders—the Lemuridæ, the Simiadæ, and the Anthropidæ.

The sub-order Lemuridæ is divided into two groups, the Lemurini, and the Cheiromini.

The sub-order Simiadæ is divided into three groups, the Arcyopithecini, the Platyrrhini, and the Catarrhini.

The Anthropidæ is represented by Man only.

The Catarrhini is again subdivided into two groups, the Cynomorpha, and the Anthropomorpha. In this last group are found the Ourang, the Chimpanzee, the Gorilla, and the Gibbon.

Comparing the Anthropomorpha with Man, we may say that the Ourang is nearest to Man in the number of ribs, each having twelve pairs, and in the form of the cerebral hemispheres. The Gibbon is most like Man in the character of the thorax. The Chimpanzee is nearest to Man in the character of the cranium, in its dentition, and in the proportional size of its arms. The Gorilla, sometimes as much as five feet six inches in height, is nearest to Man in the proportions of the leg to the body, and of the foot to the hand, in the size of the heel, in the curvature of the spine, the form of the pelvis, the shape of the hyoid bone, the form of the femur, and in the absolute capacity of the cranium. It also easily assumes and maintains the erect posture. All of these Apes have the much maligned appendix vermiformis. There are not a few distinctive peculiarities in the myology of the Anthropomorpha; but they are all to be met with occasionally as varieties in Man. With reference to the proportions of the different parts of the human body, it may be said that the human fœtus at half term has the proportions very similar to those of the Ape.

It can not be denied that we often see Negroes who differ but slightly from Apes; and sometimes even a white man is seen who is not far removed. Even from the experience of a single life-time the thoughtful man is led to believe that the first men differed but little from Apes, and that their Ape-ancestors differed but little from men. If we suppose that out of very many Ape-like men originating perhaps in the Tertiary age, there survived in the struggle for life two representative types — the woolly-haired and the straight-haired, and that from these ancestral types there began a differentiating descent, finally culminating in the present human family, we shall be near enough to the truth.

If every link connecting Man with the Eozoon can not be found, so can not some be found in the case of many other animals and vegetables; nor being acquainted with the history of the earth, could any reasonable person imagine that such chain could have remained unbroken. Man, however, has very near relatives in the Anthropomorpha. Says Huxley: "Thus whatever system of organs be studied, the comparison of the modifications in the Ape-series leads to one and the same result, that the structural differences which separate Man from the Gorilla are not so great as those which separate the Gorilla from the lower Apes."

We have said that Negroes are often seen differing but slightly from Apes. If this is true in the case even of Negroes seen in the United States, how readily may one believe Morland, an Austrian missionary for years to the Negroes of the Upper Nile, when he says that his work was futile, that the Negroes stand below many common animals, that they are without affection, gratitude, or feeling. In quoting Morland it must be understood that we speak only of the lowest type of Negroes.

It is not the purpose of this book to make a rigid inquiry into the question of Man's origin. There are many excellent works on this subject by most competent authors; and such must be consulted by those who wish further information on this subject.

In considering the nature of animals in general, it is quite proper and sometimes necessary to study the habits of the two sexes as related to each other; and in the case of Man, the head of the Primates, we believe that a brief explicit and truthful statement of such habits may be of value to the reader.

Of the Anthropidæ the male is generally said to be by nature monogynous, and the female monandrous; but a close study of their past history does not substantiate this teaching, and the facts of real life in these modern days must lead every thoughtful student to doubt its truth.

Polygyny in ancient days was almost universal, and was considered neither immoral nor irreligious, and polyandry was by no means infrequent; but with modern Christian nations these customs, especially the latter, are considered immoral, and made illegal. Nevertheless the Anthropidæ especially the male find means of circumventing the law. The female as a rule is sexually more temperate, and is less driven by her passions to transgress the bounds of prudence, or the customs of society. In nearly all animals the male is positive and insistent, while the female is negative and consenting. This is especially true of the anthropidæ.

With reference to the genus Homo it can be said that the male is inclined to regard the female as his by natural right, and that the female is not a little inclined to recognize his claim. He insists on his superiority, and she not infrequently answers with a nod. In the light of these facts we will in our next chapter give a succinct history of their habits as related to each other, or a history of the legal status of woman.

CHAPTER XXIV

WOMAN: PAST, PRESENT, AND FUTURE

IT is not to be supposed that woman's status would be equal to man's in a land where the leading characters were held to be sons of gods. Thus in Egypt women in general were grinders of corn and carriers of water, servants of man's pleasure: "φοιτᾶν . . . ἐπὶ τὴν Ἐννεάρκρουνον — Their daughters went down to the spring Ennearcrunus for water." (Herodotus: Erato vi. 137). Yet the remains of Egyptian civilization show us a people highly moral, polished in manners, deeply religious, and philosophical. Human life was perhaps more secure among them than among us; for they went where they wished unarmed, and without military protection. In religious matters they were very tolerant, as is shown by the fact that the Israelites, even during the oppression, were freely admitted into the Egyptian temples of worship. Women shared in the social and public gatherings; and monogyny was the general custom, although polygyny was permitted. The highest station in the land was open to woman. Cleopatra was a queen; and we are told by Herodotus that a woman, Artemisia, led the Egyptians against the Greeks. Throughout the whole land the wife was called "the lady of the house." Among such a people woman must naturally have had a higher status than among those less civilized; yet even with the Egyptians woman's status was certainly inferior to that of man. When Isaac's servant saw Rebecca at the well, she was engaged in a common duty of the female sex in Egypt. The husband was her "lord," and her freedom was limited. She was, however, supreme in the management of the household; and we have little doubt that her wishes in marriage were duly considered: "*Πόθεν δέ μοι γένοιτ' . . . γάμου κυρῆσαι*—O that a seat in the heavens be mine on which the watery vapor is turned to snow, or some bare, lonely, inaccessible hanging cliff, offering me a fathomless fall, rather than a marriage against the inclination of a wailing heart." (Aeschylus: Suppl. 792-800.)

In Persia woman was a power in the state as is clearly shown from the words of Atossa: "*τοία κακῶν ἔκπληξις . . . φρένας*— Such a blow resulting from these misfortunes fills my breast with consternation." (Aeschylus: Persæ 606.) It is shown also by the great respect paid Atossa by the Chorus: "*εὖ τόδ' ἴσθι . . . σύ πέμπε . . . ὑπὸ γῆς*—For well thou knowest, O queen of the land, that there is no reason why thou shouldst speak twice concerning those matters which are thine to regulate. . . . O royal wife, object of reverence with the Persians, send thou offerings for the dead in the chambers under the earth." (Aeschylus: Persæ 173, 623.)

As a mother the Persian woman was highly honored. This we learn from the words of the ghost of Darius, Atossa's departed husband: "*Μόνης γὰρ, οἶδα . . . ἀλλ' εἶμι . . . παράσομαι*— For I know well," says the ghost, speaking to Atossa of their absent son Xerxes, "that when he hears thee, he will yield"; and shortly after this, Atossa addressing the Chorus, says: "I now go for the purpose of meeting my son." (Aeschylus: Persæ 838, 851.) And when the Chorus stood trembling and speechless with fear before the risen ghost of Darius, he asked that his noble-born wife and partner of his bed should come, and speak freely to him of the peril into which the kingdom had lately fallen: "*τῶν ἐμῶν λέκτρων . . . . λέξον.*" (Aeschylus: Persæ 704).

Among the early Arabians woman must have been held in great esteem. The woman who visited Solomon in all his glory, was queen of Arabia; yet until Mohammed decreed otherwise woman was not allowed any part in the inheritance. Mohammed showed a sense of justice in ordering that every female should have a determined portion of whatever estate the parents had left, although even he allowed the male a double portion. Mohammed was a great character, wise in more ways than one; but his wisdom was never more wisely used than in bettering the condition of woman.

Among the Hindus woman filled a very low position. She was regarded, and is to-day, as a creature made for man's pleasure. Married generally in infancy she lived without a voice in the management of her own life; and if left a widow, immolation of herself upon the husband's pyre was preferable to a life of widowhood, which was and is one of misery and disgrace. Man was conceded the right of force, when persuasion failed. "Let a man approach a woman whose garments are pure, and address her. If she do not give in, let him as he likes beat her with a stick or with his hand, and overcome her, saying 'with manly strength and glory I take away thy glory,' and then she becomes unglorious." (Upanishads: vi Adhyaya, 4 Brahmana.) Say the Vedas: "The brihat is man, the rathantara is woman. Man is the excess, woman is the deficiency"; and again: "If a man is attached to his wife or children, perfect yoga can never be accomplished." Elsewhere the Vedas state that the souls of women, as of the inferior tribes, are doomed to transmigration until they can be regenerated in the body of a Brahman; and in the Hindu sacred books we are told that Prince Siddartha, who afterwards became Buddha, had many beautiful maidens trained in music and dancing given him for amusement and pleasure. Who can imagine a lower position for woman than one in which she lives simply to gratify the pleasures of man? So completely dependent has been woman on man in India that the English government has had great difficulty in putting down the practice of self-sacrifice on the death of the husband.

The position of woman in China, though low, is not so degrading as in India. Wives are bought and sold, and concubinage is very common among the rich. Widows are sold as concubines by fathers-in-law; and, it is said, it is nothing strange to see a woman harnessed to a plough. But by public opinion much of this harsh treatment is being done away with, and woman's position is getting more tolerable. We do not believe that this improvement is owing to anything existing in Chinese laws or customs. It is rather through the constant pressure of foreign example and education. When we think of the general intelligence of the Chinese, and of their diligence in life, we wonder why under such enlightenment woman does not hold a higher position.

In early Roman law the wife was regarded as a mere chattel; but for the husband's absolute title it was necessary that he should have unbroken possession of his wife for one whole year, as in the case of any other movable: one year's possession of a movable gave absolute title to the property. To mitigate this hardship on woman by which a disagreeable husband might acquire the power of life and death over the wife, the law of the Twelve Tables (461 B. C.) made it possible for her to escape being thus owned by being absent from her husband's home three whole nights every year. While the wife did this she barred the husband's usucapion. We presume it was not uncommon for the wife to take advantage of this law. She could then always plead that she had never been in the husband's possession for one unbroken year.

By the Roman law a father could appoint a guardian for his daughter after she had come to the age of maturity, but he could not for his mature son; for while the son above the age of maturity was not considered the subject of tutelage, the daughter was subject to perpetual guardianship.

Gaius says that this tutelage of the mature female was supposed to be because of her lightness of mind (*propter animi levitatem*). In another place he says that there was no valid reason for this tutelage, and that in his time woman was permitted to administer her own property after she had come to the age of maturity. A free-born woman was released from guardianship on becoming the mother of three children, and a freed woman on becoming the mother of four. The age of maturity with the male was fourteen, with the female twelve. The father had the power of life and death over the daughter even after marriage, unless she had been married by coemption.

By a *senatus consultum* a woman could not be a guarantor. It held that manly functions and liabilities are not properly chargeable to woman. The law of the Twelve Tables admitted the both sexes equally to succession; but the Voconian law declared woman incapable of inheriting. This law in Cicero's time the prætor extended or restrained according to his pleasure. Under the Emperor Claudius it was greatly relaxed; and finally the Emperor Julian, who was wise, upright and virtuous, sometime before his death, A. D. 363, admitted males and females to an equality in the right of succession.

As has been said, in ancient times the Roman woman was subject to perpetual guardianship. In the time of Justinian this tutelage, so unjust to woman, had ended; for she was then legally capable of acting at twelve years without the mediation of a guardian. As education advanced in Rome, woman's privileges and liberties increased until the greatest legal discriminations in favor of the male disappeared. In the beginning the thought of divorce, in the case of woman, was almost impossible; and all laws pertaining to inheritance, and the holding and management of property were in favor of man. But in the later ages, as for instance in the days of Marcus Aurelius, a woman was not compelled to live with a man with whom life was naturally painful. She could sue for and obtain divorce; she could inherit as well as man and equally with him; she could hold and manage her own property. As a wife she was no longer a mere thing to be possessed; as a mother she was greatly honored; and as a member of the community she was a great power, and had much to do in shaping the lives of men, and directing the destinies of peoples.

It is not difficult to see how these changes came about. Man had for many thousands of years lived a warrior, and as such the spoils of war were his. Through all the ages woman had been the prize of the victor. Hence the "wrath of Achilles," the destruction of Troy, and the allotment of the women after it was sacked. In a few instances woman had rebelled, had even taken her own life rather than live with the man who claimed her; but generally speaking custom and example had bred in her submission to the inevitable. But as the years rolled by society became more complex as its members increased, as it ever must; and it became safer even for brute strength to recognize tribal enactments and special laws. Thus the strength of one or of a few having to yield to the united strength of many, man became the subject of reason; and when reason rules, all discrimination in favor of any sex must surely and certainly disappear. All countries pass through similar stages; and the women of all countries having similar political forms, have lived and live under similar disability. In the days when man strives with man as beast with beast, woman is a mere thing, a chattel, not only without a voice in the country's affairs, but even in the management of her own person; but when mind rules or reason determines, woman's individuality is recognized, and her rights protected and insured.

Notwithstanding the servile state of the Roman woman, the Roman household was not without much that makes life worth living; and there were probably as much conjugal felicity, faithfulness and devotion as in the modern home. Humanity is about the same everywhere and always. As with modern so with ancient authors—some were for and some against woman; and sometimes the same author speaks in one place for and in another place against her. The charge that woman loves gossip is brought against her by Plautus: "Nam pol tacere . . . quod queant—Be sure you keep this matter from your wife; for I swear they are not able to be silent about anything." (Trinummus 800.) In another place this author says: "Eo tacent . . . quam loquens—A silent woman is always better than a talking one." (Rudens 1114.)

Terence also is not without a hard word for woman. When a father orders his son to hasten and get married, the son is made to reply: "Id mihi visust dicere... abi cito ac suspende te — To me this seems to say, 'go quickly, and hang thyself.'" (Andria 255.)

But when we look into an author for hard things against woman, we might find equally severe things against man, were we to search for them. Certainly no saying can be worse of man than Terence puts into the mouth of one of his characters: "No one ever saw faith in man."

Pliny liked woman so well that he thrice married, in each case happily, the third time especially so; and he loved even his mother-in-law to the very end. That he was not slow to praise woman we know from one of his letters wherein he speaks of the death of Fannia. "It grieves me," he says, "to see such a woman taken from the state. I doubt if any one in the future will equal her—such purity, such dignity, such sanctity, such constancy." Nor is Ovid any less uncertain in his praise of woman: "For believe me, my wife, if the sea takes thee so shall it have me." (Metamorph. 361.) And Vergil makes Aeneas say: "With a sad heart bewailing I cry again and again to my Creusa in vain. Suddenly her ghost appears to me: 'Why dost thou, my beloved consort, yield to this insane grief?

These things do not happen without the divine will.'" (Aeneid II. 769-778.) Nor does the noble Antoninus stint his praise of woman; for in a letter to Fronto he declares that he would rather live in exile with his wife than in his palace at Rome without her. We might continue such excerpts indefinitely; but we have given sufficient to judge how woman was esteemed by the Romans.

The status of the Greek woman was much inferior to that of the Roman in every way. The Athenians excluded woman from the inheritance if there were any sons, or male descendants of sons; if there were no such males, the estate went to the daughter, unless she was married, when it went to her husband. The husband who thus took the estate might bequeath the wife herself on his death, like any part of the estate, to any man whom he chose for his successor. In the face of such injustice to woman, it is no wonder that Sir William Jones says that nothing could be conceived more cruel than the state of vassalage in which woman was kept by the polished Athenian; for with reference to woman's status in Greece his words are true. She was strictly subject to the will of him who had legal possession of her body, whether father, husband, master, or captor. We see the proof of this statement in the noble Iphigenia yielding herself a propitiatory sacrifice to be offered by her father; in Polyxena offering herself in a similar manner; in Agamemnon seizing Cassandra as his prize; in Hercules seizing Briseis; and in the power of the son over his mother as in the case of Telemachus and Penelope.

It is generally believed that woman had a higher status in the days of the heroes than in later Grecian times. The people of Homeric times were far from barbaric. There were kings and councils of state, well recognized laws, expensive dwellings, vestments of costly fabrics, priest, prophet and temple, and arms skilfully devised. Homer probably flourished about 1000 B. C., at which time there was in Egypt and China a high civilization; and it is not at all likely that the Greeks could have been wholly ignorant of the attainments of the Egyptians. If one faithfully studies the heroic writings he will not find said in them anything in regard to woman very different from what Plato said five hundred years afterwards. This great philosopher sums up the duties of woman under three heads—superintendence of furniture, provisions and cookery, nursing the sick, and education of the children. Aristotle quotes approvingly an ancient author who says: "Silence gives glory to woman." This celebrated author says in his De Republica: "*Σχεδὸν δὲ ταὐτόν ἐστι . . . καὶ ἄρχοντος*—The question asked is concerning woman and child, whether of these also there are any virtues. This question must be answered in that concerning the relation of the ruler by nature to the ruled." (I. xiii. 4.) In his work De Generatione Aristotle tells us that: "*αἱ γυναῖκες οὐ φαλακροῦνται . . . μεταβάλλειν*—Woman does not become bald from the fact that in their nature they are like unto children; and that eunuchs do not become bald because they are changed into the female nature." (V. 3, 32.) Again, in his Historia Animalium this great writer says: "*γυνὴ ἀνδρὸς ἐλεημονέστερον . . . . ἐλάττονός ἐστιν*—Woman is more charitable than man, more given to tears; she is also more revengeful, fault-finding, more given to ridicule, more quarrelsome. She is also less courageous, and more despondent than man; she is more shameless and more false; more deceiving, more suspicious, more hesitating, and more inflexible, and eats less food than man." (IX. 1. 7.)

Coming up several hundred years we have Jerome, one of the most celebrated teachers in the Christian church, almost reiterating the words of Plato and Aristotle. "The duties of woman," he says, "are dispensatio domus, necessitates mariti, liberorum educatio, correctio servulorum"; at the same time he insists that these duties are prejudicial to woman's highest interests, which are best served, he says, only in the unmarried state.

We believe that the words above given from Plato set forth the general idea then existing on the duties of the female, rather than the thought of Plato himself; for he distinctly teaches elsewhere that there should be no discrimination made against woman in education; that she should be taught the same branches as man; that she is not inferior to him; and that even physically it might benefit the race for her to be taught the same or similar exercises.

In the days of the heroes the Greek husband could have as many concubines as he was able to support, but he could not have more than one wife, who reigned over the whole internal life of the great house. In this relation Agamemnon was allotted Cassandra as his prize by the Grecian army: "*στρατοῦ δώρημα*" (Aeschylus: Agam. 955); but the power of his wife over her is clearly shown in Cassandra's lamentations: "*ὀτοτοτοτοῖ ποποῖ δᾶ*" (Ibi 1072-1083); and finally in her murder: "*κτενεῖ με τὴν τάλαιναν*" (Ibi 1258-1261); and by the fierce jealousy of Clytemnestra which finally impelled her to murder her husband. We learn from these facts that the man who used these privileges, did not have a path of roses: "*οὗτός ἐστιν Ἀγαμέμνων νεκρὸς*" (Ibi 1403-1406).

Concerning the custom of having concubines it must not be forgotten that the habits of society in those days and the general condition of the world, made those who lived then and those who live now, judge such relations quite differently. Men in those ages were not without affection for those near to them. It would be hard to find in these days more beautiful sentiments than we find expressed in those days by members of the same family toward one another. A wife's desires were frequently yielded to by the husband, and her counsel often determined or modified his action. Socially she was by no means a slave, nor a person that might be ignored; although legally her whole life was indeed one of servile dependence. In the case of Penelope already mentioned it is true that the suitors were passionately wooing her, sitting in the great hall all day long trying to charm her heart with presents and flattering words; but Telemachus her son says that he *will order* her to get married, although he does add that he will permit her to *choose from among them*: "*κελεύω . . . . ἐθέλῃ*" (Odyssey xx. 341.) This is sufficient in itself to show that the status of the Greek woman was a low one. We should also not forget that this being true of Penelope, the most beautiful in form, the most adept at artifice and cunning, and filling the highest social rank, the wife of a petty king, it must have been much worse for the average person of her sex: ‘*οἵη νῦν οὐκ . . . . μελαίνης*—For there is not another such woman throughout the Achædean land, nor in sacred Pylos, nor in Argos, nor in Mycena, nor in Ithaca itself, nor on the dusky mainland." (Odyssey xxi. 106.)

In the days of the heroes woman had no right to resist when the authority over her determined on her betrothal; but we may believe that Priam, so much beloved of his children, and so much adoring them, would not have promised his daughter to Othruoneus, unless the latter was known already to have made a favorable impression on Cassandra. The Greek did not think it right to force a woman to accept a man she disliked: "*τί παρθενεύει, ἐξόν σοι γάμου*—Why continue so long a virgin when you have the chance of a grand marriage?" (Aeschylus: P. B. 648.) Legally, however, the woman was nobody, nothing; she was a mere thing, absolutely subject to the will of others. In the case of Othruoneus we are simply told that he asked the king for the hand of his daughter, and that the king consented, provided the young man joined the Trojan forces, and returned with a good name: "*ᾔτεε . . . εἶδος ἀρίστην.*" (Iliad xiii. 365.) We see also how little self-government was allowed to woman in the case of Helen and Paris. An honored guest from a neighboring kingdom seizes the wife of his absent host, and bears her forcibly? to a foreign shore. Some time after, while resting from the dreadful battle, in which so many of the Trojans had bitten the dust, Hector thus upbraids him: "Μιχθεὶς ἀλλοδαποῖσι . . . ἀνῆγες— Committing adultery thou leddest a beautiful woman from a far-off land, a relative of mighty warriors, to be the bane of thy country, the city, and all the people. Wouldst thou withstand the godlike Menelaus? Knowest thou the kind of warrior whose wife thou hast?" The nonentity of woman is further shown in the case also of Achilles and Briseis. Briseis is not consulted in the matter. The lust of the warrior alone determines his action; and when that was not fully gratified, he retired from the Grecian forces, and recking not, permitted the slaughter of tens of thousands of his countrymen; and when Agamemnon, desiring her for himself, sent his heralds to take the girl away by force from the tent of Achilles, they were warned to tell the king that he would rue the day for thus "dishonoring the best of the Greeks":"Ἀγαμέμνων ἠτίμησεν." (Iliad I. 322; XIX. 136.) Further proof we may adduce in the case of Andromache, the beautiful wife of Hector. In one of the most touching scenes of the Iliad we have noble Hector admitting the possibility of the ravishment and enslavement of his wife: "χυτὴ καλύπτοι—Ah," he says to his weeping wife, "that I may be present when thou art in need of me to ward off the day of slavery. May the fates bury me below the heaped-up earth before I hear thy cry for help, while thou art being borne ruthlessly away." (Iliad vi. 393-464.) Poor Hector was buried, and his wife cried in vain. Troy having fallen she was allotted to Neoptolemus, after her little son was barbarously murdered by being hurled from the walls. Her royal mother-in-law Hecuba was allotted, some say, to Ulysses, and sometime afterwards in despair threw herself into the Hellespont. We might fairly conclude from the above that where woman to-day is allowed the last word, in the days of the heroes she showed her servile state by discreet silence. It would not be strictly correct, however, to hold that woman was not at all respected in heroic times. We find her—

Specially conspicuous in divine service, as in these days. When his mother besought Hector to rest awhile, and take refreshments, he replied: "*μή μοι οἶνον . . . μῆτερ*—No sweet wine for me, dear mother; but go thou with the reverend dames to the temple of Athena, taking with thee the most precious robe, and lay it upon the knees of the fair-haired goddess, that she may have mercy on the city, and on the tender little ones and wives of the Trojans." (Iliad vi. 264, Odyssey xvii. 50.) Not only was woman conspicuous in worship, but she might be even chief priest: "*Κίσσηϊς . . . νήπια τέκνα*—For Cisseis, wife of horse-taming Antenor, the Trojans had made chief priestess of Athena. Wailing they all reached forth their hands to the goddess; and the beautiful cheeked Theano, taking the sacred robe, placed it upon the knees of the fair-haired goddess, and imploringly prayed to the daughter of the great Jove: 'O dear Athena, city-protector, goddess of goddesses, break thou the spear of Diomedes, and grant that headlong he fall before the Scæan gates. So will we offer unto thee in thy temple twelve perfect heifers, if thou takest pity on the city, and on the little ones and wives of the Trojans.'" (Iliad vi. 299-310.)

We further see that woman was held in high esteem by the fact that though the father had power of life and death over her, he nevertheless appeared generally delighted to oblige his daughter: "*οὔτε τοι ἡμιόνων φθονέω*—My dear child, I do not deny thee the mules nor aught else thou askest. The slaves will prepare for thee the high-walled chariot constructed with the upper framework." (Odyssey vi. 65.) And when Chryseis, daughter of Chrises, priest of Apollo, was taken prisoner by Achilles, and allotted to Agamemnon, the father went in wrath to the tent of the king, and demanded his daughter, threatening the Greeks with every divine curse unless his demands were complied with, and promising a safe return from the war with Troy, if his daughter were given over to him. (Iliad I. 10, 30, 96, 372, 441.)

Woman was respected and loved by her husband. We hear Oedipus crying out in his despair: "O beloved head of my wife Iokasta!" (Aeschylus: O. T. 950); and Ajax cries: "As the hot iron is cooled by the water, so am I unmanned at the words of my wife. I pity her left alone with my enemies." (Aeschylus: Ajax 651.) And Clytemnestra is very bold, pleading justification for the awful deed she had done: "*ἄτιμα δ' οὐκ ἐπραξάτην*." (Ibi 1438.) So just before the dreadful battle when the noble and affectionate Hector feared he would never see Andromache again, he visited his wife, took the little child in his arms, and affectionately fondled it, and used the most endearing terms to his wife. So with Ulysses: in all his wanderings he frequently expressed his desire to see his wooded Ithaca again, where wife and son were anxiously awaiting his return. In the case of Alcinous we are told that he honored his wife as no other woman in the land was honored (Odyssey vii. 65-77); and in some of the plays of Euripides we see the husband manifesting intensest grief at the loss of his wife: "*ἔλιπες ἔλιπες . . . ὀρφανεύεται*—

Thou art gone, thou are gone, thou dearest and best
Of all women whom the ray of the sun,
Or star-faced moon of night beholds.
Woe is me, such evil has befallen my house.
For thy fate are my eyelids covered with tears.
O that the clouds, the clouds might settle on the earth,
And I, wretched one, die in darkness,
Deprived of thy most beloved companionship.
Woe is me for thee, pitiable one, such affliction in my house
Do I see intolerable, unspeakable. I am ruined;
My home a desert, my children orphans." (Hippol. 836-854.)

In another place Euripides shows a husband's sufferings so intense at the loss of his wife that Achilles, who happened to be a guest, was moved to descend into Hades to rescue her spirit from the clutches of Death: "στυγναὶ δ᾽ ὄψεις . . . ἀποσυλήσας—

> Alas, alas, hateful is the sight of the house.
> Where shall I go? how stand? what shall I say?
> What not? How utterly ruined am I!
> Ill-fated the mother who bore me.
> I envy the dead, and wish to be with them.
> There desire I to have my home;
> For I neither rejoice in the light of the sun,
> Nor in treading on the earth;
> Of such a wife has Death deprived me,
> Giving her over to Hades." (Alcestes 862—.)

Because of this violent grief we have Achilles declaring his resolve to descend into Hades, and bring back the spirit of the dead to the afflicted one: "ἐλθὼν δ᾽ ἄνακτα . . . ἐμοὶ μεθῇ—

Going among the dead, black-robed unconquered Death
Will I seek, and I think I there shall find him
Drinking near the tomb of his victims.
And if pursuing driving him from his seat
I find him, and throw around him my circle with my hands,
There will be none who shall deliver him
In distress, until he shall have delivered to me the woman."
(Alcestes 848—.)

In Sophocles we find the most endearing sentiments expressed by Ajax and his wife: "ὅταν κατεύχῃ . . . τεθνηκότος—When thou prayest for such," she says, "I beseech thee to pray at the same time for my death. For what is the use for me to live when thou art dead?" (Ajax 393.) To which Ajax replies: "οἰκτείρω . . . . λιπεῖν—It pains me to leave my wife defenceless with my enemies, and my child an orphan." (Ajax 653.)

Woman's honor was greatly esteemed in the days of the heroes, and her wrongs terribly avenged. It was to avenge the wrongs of woman that the expedition against

Troy was carried out. The army made the wrongs of one the wrongs of all; and the common cry was: "*τῷ μή τις πρὶν στοναχάς τε*—Let no man think of returning home until the woes and ravishment of Helen are avenged." (Iliad ii. 354.) Nessus also forfeited his life for *his* dishonorable act. (Sophocles: Trach. 565.)

The highest station in life was not refused a woman, for she could be queen or co-ruler, as the strange young guide informed Ulysses: "*οὗτος δή τοι . . . νείκεα λύει*—This, respected sir," she said, "is the house you wish me to describe. You will find two god-sustained rulers sharing the throne. The queen you will find in her mansion. Her name is Arete, and she is of the same descent as her husband Alcinous. Turning a sea-purple spindle she sits near the hearth in the bright rays of the sun, leaning against a pillar, wonderful to see, her slaves attending her. Near her stands the throne of my father. He and the children honor her as no other is honored of all wives who share the homes of men; and so the people, looking on her as if a god, praise her as she passes through the city. For she lacks nothing in nobility of soul; and on whom her graciousness is shown, for them in strife she acts as mediator." (Odyssey vi. 303, vii. 48.)

As men in these days often ask the advice of a good woman, so in those days. When Hector was fleeing to escape the wrath of Achilles, it was a woman who said to him: "Come now within the citadel. Do not make thy son an orphan, and thy wife a widow." (Odyssey vi. 431, 153, 186; Iliad vi. 431.) So was it a woman who defied the authorities, and said: "*ἐγώ σφε θάψω . . . πόλει*—Come what will, I will bury my brother; nor will I hesitate in this to defy the laws of the state." (Aeschylus: Thebes 1028.)

In the days of the heroes woman was greatly loved as mother: "*ἡ γὰρ νέους . . . . τόδε*—It is she," says Eteocles, "that guides the creeping nurslings, and tenderly caring for every childhood suffering, raises the faithful home-builders and shield-carriers, that you may be prepared for such an emergency as this." (Ibi. 17.)

When Odyssey saw his mother Anticleia in Hades, struck by her forlorn appearance, he rushed after her, pursuing the ghost hither and thither, and tried several times to embrace her. (Odyssey xi. 210.) When Telemachus had prevailed on the suitors to contend for his mother's hand, he entering the contest himself said, "If I shall win, my dear mother will not leave me for another" (Odyssey xxi. 114); and when Hecuba saw her dear son pressed by Achilles, knowing he was not equal to his pursuer, she cried: "O Hector, my child, my child, whom I bore, and nourished, regard thou these facts, and come within the walls" (Iliad xxii. 82); and when Sochus lay dying, smitten at the feet of his victor, Odyssey, the bitterest words the latter could utter to the dying were to tell him that no tender mother would close his eyes in death. (Iliad xi. 453.) When Achilles was suffering the direst agony, it was to his dear mother, who bore him, that he turned to in despair. (Iliad i. 352.) It is also a mother whom Euripides gives us as ready to lay her life down to save her child from death: "*τί δῆτ' ἐμοὶ . . . ἀπωλόμην*—

What is there sweet in life to me? To what can I look?
One child was left to me, the eye of my life.
Now they are about to kill this.
To me it were a disgrace not to die for my child.
O child, she who bore thee will go to Hades,
That thou mayest live, and escape the fates.
Remember thy mother how deploringly she died."
(Andromache 404.)

Woman stands forth as a loving sister in the days of the heroes. When Electra's young brother was threatened with death, she used all the cunning of a woman to devise a plan by which he might be rescued. She finally sent him in the care of a slave to King Strophius in Phocis, where he was brought up, and educated with the king's son, Pylades. When grown he sought, and after much labor found his sister, who had been his salvation; and in his admiration he exclaimed: "ἄτιμος οὐδενὸς σύ—There is nothing of which thou art not worthy." (Sophocles: Elec. 1215.)

In the days of the heroes woman often stands forth as the country's salvation. When the Argive host seemed in danger of destruction, it was Macaria who by her self-sacrifice enabled Demiphon to win the day. "It is willingly," she cried, "that I give my life for this cause." (Euripides: Herac. 550.) And we find Polyxena a no less willing sacrifice, when her country was in danger: "Take charge of me, Odyssey," she said. "Cover my head with my cloak, lest on the threshold of death I weaken my spirit through my mother's lamentations, or I weaken her by my groans. O light of the sun! for as yet it is permitted me to speak thy name; but no longer art thou mine except sufficient for me to be knifed at the tomb of Achilles." (Euripides: Hecuba 383.)

Some of the Greek writers have been set forth as enemies of woman, and none more so than Euripides; but in our judgment the latter at least is not worthy of this censure. Euripides was the son of Mnesarchus and Clito, and was born at Salamis B. C. 480. He studied physics under Anaxagoras, and rhetoric under Prodicus, and was intimate with Socrates. He was a great student, was of melancholic temperament and serious disposition. He was twice married, his first wife being called Melito, his second Choerila. He had three sons, Mnesarchus, Mnesilochus, and Euripides. The first play exhibited under his own name was the Peliades; and in 441 B. C. he gained the prize. Very many were envious of his prestige, and he had many rivals among the poets. Through the machinations of some of these it is believed he came to his dreadful death: he is said to have been torn to pieces by the king's dogs B. C. 410. He was buried in Macedonia. In all ninety-two plays are attributed to him, of which there are extant seventy-eight titles, and eighteen plays. Euripides loved philosophy; and such mental bent made him a severe critic of the morals and theology of the age. His scepticism is everywhere manifest. Observing the prosperity of the wicked, and the penury of the righteous, he expresses his doubts of the existence of an all-ruling Providence. If there is a God, he says, he must be good and just; but the condition of mankind is such that neither goodness nor justice can be conceived as ruling the affairs of men. He was therefore called by many an atheist. In his criticism of the female sex he was severe. The women of his day disliked him; and by many of his contemporaries he was considered a misogynist, which he certainly was not.

The force which brings the sexes together is not an artificial one, nor of any peculiar age nor time, but universal and natural. What hemoglobin is to the blood, oxygen to the lungs, blood to the heart, the sexes are to each other. As a person may exist with any or all of these in an abnormal state, so man and woman may exist apart from each other; but they can never enjoy nor experience the fulness of life. For two reasons nature has rewarded the normal congress of the opposite sexes with a gratification *sui generis* — that the race may be perpetuated, and that some atonement may be experienced for the superabundant evils of life. The sense of this gratification is latent at least in every normal being; and silently draws the opposite sexes together, frequently against reason or their will. This being universally true it is impossible for any truly philosophic mind to be misogynistic or woman-hating; and therefore it is impossible to believe that Euripides was such. Again, Euripides was twice married; a woman-hater is not inclined to marry even once. His first unhappy union did not deter him from a second trial; and in this he showed his good sense.

No one is sure of a happy married life; but every one may be sure that neither man nor woman is in nature fitted to live alone; that however unhappy they may be together, apart from each other complete happiness is unthinkable. The conditions of life should be such that neither man nor woman should be compelled against their will to enter into matrimony. Innumerable persons physically, psychically, temperamentally, or because of disease are naturally unfitted for marriage. There are also cases, males and females, where mankind is vastly more benefited when such individuals give themselves to independent endeavor, remaining unfettered by family ties. No woman therefore should be forced to marry, because of discriminating industrial customs or legislation, either to support herself or others dependent on her. Aeschylus says well: "*πῶς δ' ἂν γαμῶν . . . πόθεν δέ μοι γένοιτ' . . . ὁ μέγας Ζεὺς*— How can any one be good entering into marriage relations unwillingly made? Not even by death can one escape in Hades the results of such foolishness. . . . O that a seat in the heavens be mine on which the watery vapor is turned to snow, or some bare lonely inaccessible hanging cliff, offering me a fathomless fall, rather than a marriage against the inclination of a wailing heart. . . . O great Zeus! deliver me from this marriage." (Suppl. 227, 792, 1053.) That wedlock accomplish what nature intends, the force that leads to marriage must be above the cry for bread or the longing for gold. Yet though these things are true, it remains that man and woman have sought each other from the beginning; and it is certain they will continue to do so to the end.

That persons unhappily mated should be embittered against each other's sex is only natural, considering how prone persons are to hasty conclusions; and knowing the great disappointment such individuals experience, finding Tartarus where they expected to find Elysium. Thus

Euripides can not refrain from censuring woman-kind: "*μισῶν οὔποτ'* . . . . *γυναῖκος*—

> I shall never cease hating woman,
> It matters not who says I am always guilty of it;
> For in some way or other they are always evil."
> (Hippol. 665.)

Again: "*ὡς δὲ μὴ μακροὺς τείνω*—

> To make a long story short,
> If any in the past has spoken evil of woman,
> Or now speak or shall speak,
> I cut it short by saying I confirm it all;
> For neither earth nor sea contains such another species."
> (Hecuba 1175.)

Again: "*οὐδὲν* . . . *οὕτω*—

> Nothing is so terrible and evil as woman.
> No indictment could contain such evil,
> Nor utterance set it forth. If any of the gods
> Moulded her, let him be known, being a contriver of evil,
> As the greatest plague of mortals." (Fragment 880.)

Terrible as this arraignment of woman is, it all flows from the font poisoned by his own unhappy experience. In his dispassionate moods, or when using his own critical judgment; or when feeling his own responsibilty as teacher, counsellor, philosopher, he goes deeper into his manhood, and draws from nature itself. No pen has ever described a mother's love, a sister's affection, a daughter's consecration, a wife's devotion in more glowing terms than that of Euripides. When speaking of the evils of married life, he dipped his pen into the ink manufactured out of the gall of his own life; but when speaking of the true union of man and woman, or when he speaks of woman in general, then his serious, thoughtful, polished mind expressing the conviction of his own unbiased soul, could find no words of praise too great to express his admiration for woman: "ὅστις δὲ—

Whoever speaks slightingly of womankind,
Is empty-headed, not wise." (Fragment 652.)

Again: "κἀν ταῖς κακαῖσιν—

We good women are hated,
Confounded with the bad." (Ion 398.)

Again: "γάμοι δ' ὅσοις—

Those who are well married, are always happy;
Those who are not, have unhappiness within and without."
(Orestes 602.)

Notwithstanding the unhappy married life of Euripides, there must have been times when he tasted the depths of woman's love, as the following shows: "γύναι, φίλον μὲν φέγγος—

O woman, dear is this ray of the sun;
Sweet is it to behold the pleasant ocean wave;
Beautful the earth bringing forth its springtime, and abundant rains.
Of many beautiful things can I speak the praise;
But nothing is so radiant and beautiful
As to see in the house the light of little ones."
(Fragment 327.)

What woman-hater, or who esteeming woman lightly, could give us the characters of Hecuba and Polyxena? So dear is her child, so deep the mother-love, that she begs Odyssey to intercede for her with Agamemnon that she may be sacrificed instead of her daughter; and if this is impossible, then that she be sacrificed with her, assuring Odyssey it would be specially good for the Greeks, being a double blood-offering at the tomb of the son Peleus. On the other hand the daughter begs the mother to dry her tears, saying that she was not at all unwilling to yield up her life, death being preferable to life with dishonor. (Hecuba 383, 432.)

Yet further proof have we of Euripides' admiration for woman. No greater patriotism was ever shown than this author gives us in his "Iphigenia in Aulide." The Grecian fleet on its way to Troy was storm-bound at Aulis; and the prophet Calchas declared that there was no salvation except by the sacrifice of Agamemnon's daughter, the beautiful Iphigenia, who was then on the eve of her marriage. The king had vowed to Diana the most beautiful thing the year of her birth had produced; and this was admitted by all to be Iphigenia. In vain did the father by every cunning seek to evade his vow, and the wrath of the mother; but deep murmurings arose in the army at the king's lack of piety, and not even Achilles, with the promise of having the beautiful Iphigenia for his wife, could stem the rising indignation of the men. At this point, and to relieve the father, Iphigenia comes forward offering herself a willing sacrifice for the salvation of Hellas, assuring her father and mother that for no greater cause could a person be born than to die for his country, and that no more glorious death could ever be hers than to offer herself a willing sacrifice for the salvation of the Greeks: "ὡς εὐτυχοῦσα . . . . ἐξαλείψω—

As the good fortune and benefactress of Hellas
Me unwillingly does my father immolate.
Thou didst nourish me, my mother, for a light to Hellas,
And dying it will shame me not.
Ray of God! another age shall we possess.
Rejoice with me beloved light.
Lead me around the altar, as I go to give
Victory-bearing salvation to Hellas.
Lead me for the destruction of Troy
And the Phrygians.
Bear, throw around the encircling wreath.
Here is my head to crown.

Bring the font of holy water.
March around the temple of Artemis,
The conquering Artemis,
The happy: that with my blood,
The sacrifice decreed,
I this atonement make." (Iphigenia in Aulide 1447-1509.)

This awful sacrifice of Iphigenia so aroused the wrath of the mother that Sophocles makes Clytemnestra say it was this that led her to murder her husband Agamemnon: "*ἐπεὶ πατὴρ . . . θῦσαι.*" (Electra 530.)

Man may enter the army, and obey the bugle's call; but he goes with the expectation of returning. Men are not known to offer themselves without hope of salvation; nor are they so depicted by brush or pen. But in this last play of Euripides we have a beautiful girl who for the love of her country makes a willing sacrifice of herself upon the altars of her country's gods. In this sacrifice we have the highest filial love, the greatest bravery, and the deepest subjugation of self for the welfare of her native land. While the mother protests, and declares the presence of her daughter at the place of sacrifice to be the result of royal deception, treachery, cowardice, and cunning, this noble and beautiful girl begs the mother not to forget the dilemma the royal father was in, nor to disparage the great honor the divine powers were bestowing on her in permitting her self-immolation.

In the fact of such teaching how can one charge Euripides with depicting woman as base, treacherous or unfaithful? True enough he gives abundant examples of the baseness and wickedness of women (nor for the like in man had he far to go); but he is not unmindful of the noble and incomparable deeds of his mother's sex, nor slow with his pen in drawing for them a crown of everlasting glory.

The Law of Moses: It is a long leap from the heroes to the children of Israel; but it is doubtful that the status of the Israelitish woman was any better than that of the Greek. The law of Moses gave a double portion of the inheritance to the eldest son, and excluded the daughter entirely, if there were sons or descendants of sons; and when the inheritance in default of sons went to the daughters in equal portions, they were obliged to marry in the family of their father's tribe, in order to keep the inheritance within it.

Among Uncivilized Tribes: To-day among uncivilized tribes woman stands no higher than she stands in India. She is a mere thing to be possessed, a mere chattel for barter or exchange, or disposal at will. With some tribes, on the death of the father, his widows become the common concubines of all the sons, each son, however, keeping apart from his own mother; with others a brother's widows go to the remaining brothers; and in the case of self-immolation, where only one can die to accompany her lord, the different wives contend with one another for the honor. Among uncivilized people woman in general is entirely subject to man; yet there are not wanting exceptions. Spencer tells us that when a woman dies among the Kocchs the family property goes to her daughters. Among the Karens the widow may use the property till her death. With the Khasias the home belongs to the wife, and in case of the husband's death or separation from her, it remains her property. This is a good custom, and should prevail everywhere. Among the sea Dyaks the woman in case of divorce gets half of the joint property. Among the Nootkas on being divorced the husband and wife divide the property equally. The Iroquois had descent in the female line, and the property of the wife remained hers after marriage; and if husband and wife separated, the children, if there were any, went with the mother. In this the Iroquois showed that they were wiser than we.

Yet among uncivilized tribes in general the woman is the prize of the strong. Her strength is contemned. Says

Hercules: "*νῦν δ' ἐκ . . . εὕρημα τάλας*— From this time I, unfortunate one, am only a woman." (Soph.: Trach. 1077.) And in another place this same author makes Chrysothemis say: "*γυνὴ μὲν, οὐκ ἀνὴρ ἔφυς*—I am not a man in nature." (Elect. 997.) Among such tribes woman may be stolen, knocked down with a club, speared, captured, and used at the captor's will, and afterwards be forced to do all the drudgery. With the Indian the wife was his beast of burden, as she is the Kaffir's ox. When the Tupis migrate the husband carries only his weapons, while he loads his wife like a mule. The Fijian might kill and eat his wife at his lordly pleasure; and then get a new one to use for a time, and then fatten for a future feast. There are not wanting, however, a few tribes where men do the work commonly belonging to woman, such as keeping house, cooking, sewing, spinning, weaving, washing; and among some few peaceful tribes the woman fills a high position.

In the Common Law: In the Common Law a married woman has about the status of an infant. "It is a well recognized principle of English and American law that wherever the wife is the meritorious cause of action, the husband must join the plaintiff." (Schouler.) To-day, however, "an unmarried woman is considered an independent person." (Dicey.) Married women are with us anything but independent. Says Savigny: "By many positive laws woman requires the concurrence of a guardian; by others she needs the consent of her husband." Schouler, a present authority on the status of woman, says, "If the right of the woman has been legally speaking at the husband's mercy, her constant desire to please him has kept him generally merciful." Such a sentence as this does not speak well for the lawyer who wrote it, nor for the people who could permit such laws or customs to exist. Woman does not ask mercy; she should refuse to have it; she wants justice, and she should demand it.

She gets justice when she stands on perfect equality with man or with her husband, and not before. We are glad that woman is gradually coming out of this servile state. At the Common Law she was to a great extent the slave of her husband; to some extent she is to-day. At the Common Law the husband could chastise his wife, direct and demand her labor or service, and receive whatever money was due her, and give receipt for the same. "The general tendency of public sentiment," says Cooley, "as well as modern science has been in the direction of doing away with the arbitrary power which the husband formerly had, and of placing the two sexes in the marriage relations upon a footing nearer equality. It is believed that the right of the husband to chastise his wife would not be recognized in this country." We are glad that the Married Woman's Act in England (and similar legislation has been enacted in this country) has given woman a higher status. She can now even sue for money which she has earned, and manage her own property. Much of what she might enforce in times past in a court of equity, is now a part of her legal right. She is no longer, thank God, a mere slave of a man called her husband, although very possibly infinitely inferior to her, and perhaps a common drunkard.

Dreary indeed was the life of woman in early Greece and Rome, bound to a disagreeable man; and equally dreary were her life in these days, were she not protected by reasonable divorce laws. For the sake of our sisters and daughters we should always try to paralyze the hand that would make divorce impossible; for however firm the marriage-knot, it should never be so firmly tied that it can not be undone. By whatever door one enters into marriage, there should always be a door out of it, although it should be with difficulty opened. This necessity was seen in ancient Rome, and finally provided for; this necessity is seen everywhere to-day, and provision must be always made for it. Indeed the status of woman may be judged in any country by its laws on divorce. The more indissoluble the matrimonial tie, the farther is woman from equality with man. As we do not believe in forced marriages, so do we not believe in holding together by force those that naturally repel each other. Because persons not suited to each other are foolish enough to wed, impelled by animal impulse, the law should not be so unjust and irrational as to force them to live together knowing each other's mutual disagreeabilty. A happy wedded life is the acme of blessedness; an unhappy one, an abyss of misery.

In early Greece and Rome we have said that the home-life of those who were agreeably mated, would compare favorably with our own. In those days as in these, the peril of woman lay not in being in the power of a good and noble man, for everything is safe there; but in being in the power of an incapable, libertinous, intemperate, or unreasonably jealous one. To a woman however good united to a man of such character, there was and is a hopeless existence; and without the right of divorce there is no escape for her. Nor should the child be forgotten; for hateful as is life to a man and woman in a loveless home, to a child it is truly blighting. And since the vast majority of men are not good and noble, for the sake of our daughters and sisters there should be legal escape from the insufferable yoke of a disagreeable marriage.

The problem of life should not be how to die rich, nor how to live a centenarian; but how to live happily and well. Since man must die I can not see it matters much whether we die early or late, provided no one is dependent on us. If Christianity be true, he who has lived well, though it be a very short life, is certainly more blessed dead than alive; and if it be not true, philosophy assures us that living things as a rule do not perish until they have accomplished their end. Nor should one make the so-called physical improvement of the race his object in life. I do not know that the small working ant is any less happy than the larger male; or that the Chinese being physically larger than the Japanese get more pleasure out of life than the latter. As far as reason goes a race of men averaging no more than four feet in height were as happy as one averaging eight. The aim of life therefore should be happiness; but this aim is made absolutely unattainable in the case of a man or woman unhappily married, and without the right of divorce. The cohabitation of man and woman against the natural inclination of either must ever be regarded as a much greater evil than for one to remain unmarried. He who would legislate to make divorce impossible, is like the man who adds to the height of the wall to dam back the ever-increasing flood. Such pent-up fury must have an outlet. The first Napoleon said, "Le mari doit avoir un empire absolu sur les actions de sa famme"; and such is the desire of all who are selfish and unjust.

Those who wed should fully understand that the union of man and woman in marriage is intended to be life-long; and they should know that the deeper joys of such union come to those only who grow old together. Happy are those who make such choice that they can remain steadfast and true as sharers of each other's joys and sorrows unto the end.

Woman's Future:

We do not see how any man with a fair education, who has breathed from childhood the air of a liberty-loving and fair-minded people, can regard the female sex as inferior to his own; yet the very atmosphere in which we live is saturated with woman's fancied inferiority—an inferiority insisted on by the majority of men, and admitted by not a few women. I have wondered at this the more, seeing as I have seen that it matters not in what grade of the high school, or in what year or department of university study, or whether in the study of law, medicine, divinity, language, or what not, the female students were very rarely seen inferior but frequently superior to the male students in general. It is true you sometimes hear a man admit woman's equality. But it is nearly always done in a spirit of *noblesse oblige.* Many thousands of years of custom supported, in most parts of the world, by the teachings of religion, and sanctioned by law, might be a sufficient explanation for the recognition of woman's inferiority among the ignorant classes; but it is no honor to the world of intelligence that the same idea prevails, to a great extent, among the educated. The fact that the woman takes the name of the husband in marriage, and the children of the union the name of the father, has probably been no small cause of creating in man a sense of woman's inferiority; but even this has not been a universal custom. There have been people who named their children, and very rightly in our opinion, after their mother, and not after their father. (Herodotus: Kleio 173). Every child is truly built up of its mother's substance. Hers and not the father's is the plasma out of which the child is moulded. Woman absolutely knows when she gives birth to a child, she knows when she is a mother; but the reputed father does not often *know,* however much he believes that he was a co-worker in its genesis. The Latin poet says: "Quod peto aut quod uolo parentes meos ut conmonstres mihi." To this inquiry of the son, the father replies: "Crede et nostrum te esse credito." (Terence: Heauton Timorumenos 1034.) Few of us like such distrustful questions or thoughts; few of us have any reason for doubting our mother or her words. Yet faith, trust, is one thing, and certainty is another; and it is of certainty we speak. This unquestionable truth should be sufficient reason for naming the child after its mother. Another reason for so naming the child is the unquestionable fact that the mother is the greater centre of family life.

It is the writer's unshaken belief that in honesty and efficiency, wherever woman has put her hand, the result of her work, she persisting, has in no way been inferior to man's. Where may we find greater characters than Semiramis, Catherine de Medici, Elizabeth, Maria Theresa, Isabella, Lady Montague, Victoria? The present Kaiser of Germany is rightly regarded as an able man. Is not his superiority derived from his mother? Is not every woman in Germany indebted to the noble English wife of Frederick for what she did to elevate the status of her sex throughout that country?

It is true enough that in most spheres of effort man has passed woman; but this is no more proof of his superiority than that one man who has lived seventy-five years, and accomplished much, is superior to another who has lived only thirty-five years, and accomplished little. Custom has generally led woman to turn aside from certain activities before she could possibly make a name for herself, such as she otherwise would make. There is not one scientific fact known to the world for belief in man's superiority. I know that woman in general is said to have less weight of brain than man, the average weight of the brain of the latter being about forty-nine ounces, and that of the former about forty-five; but it is extremely doubtful that the intellect is proportionate to the weight of the brain. This doubt is admitted by such as Gray in his Anatomy, and Kirche in his Physiology. Some very ignorant people have had very heavy brains. Dr. Haldeman of Cincinnati mentions a mulatto whose brain was sixty-eight and half ounces, who gave no evidence of superior ability; and Dr. Berksdale, of the Virginia Lunatic Asylum, once reported a case of a negro whose brain weighed seventy ounces. It is perhaps true, as it is quite generally held, that the degree of intelligence does correspond to the complexity and depth of the convolutions of the gray matter of the cortex; but we doubt that in the male these convolutions are either more complex or deeper than in the female. It is altogether probable that the complexity and depth of the gray convolutions are the result of function. It is quite likely, for instance, that the brain centres for the love of certain sports in man, and those for the home circle in woman have not been equally developed in the two sexes; nor need it be doubted that this has resulted from the fact that the two sexes have given their energies to the engagements each loved best. Whatever aptitude man may show superior to woman's for certain avocations, we are sure that when a woman is permitted to engage in those pursuits for which he seemingly shows superior ability, she will not long be surpassed by man. While we believe that there are certain avocations for which man is more peculiarly fitted than is woman, we insist that these will grow less in number as life becomes more complex. In every civilized country the barriers set up from time immemorial preventing woman from entering into certain pursuits, are breaking down; and whether for weal or woe, in our opinion they never can be set up again. Neither in anatomy nor physiology is there anything to support man's claim to superiority in general. Even strength of bone and size of muscle is not the peculiar gift of nature, but simply the result of special activities; and the activities to which one gives himself, are ruled by custom.

We are most everywhere and by nearly everybody told that marriage and motherhood should be the one aim of a woman's life. We answer that society has no greater right to demand the sacrifice of woman for the race than of man; but sacrifice herself she must, if woman lives with such an idea uppermost in her mind. The chief aim of woman should be that of every living creature—to better her own condition, and elevate her kind; and this means to live on the highest possible plane. The aim to live thus is manifested by every living organism, by every animal, therefore by man, although some make haste to deny it, only by this denial to give it greater confirmation. While woman makes marriage her one aim in life, she brings upon her sex several evils: she fails to do her part in elevating her kind; she subjects herself to the probability of being ill-mated in wedded life, and to the great possibility of being a cause of suffering and sorrow to those who love her best. The earth is not to-day crying for people to come in, and possess it. There are no Abrahams in our days journeying from the land of Ur into that of Canaan to dispossess the original inhabitants, and to possess it forever. Neither man nor nation to-day dares to claim any peculiar covenant with God. Each has to keep his powder dry, and fight his own battles. The land is already possessed by those better able to hold it than we are to put them out. While we are attempting to dispossess others, we ourselves may be dispossessed; and even what we now cherish, may be taken from us. It is not wise therefore to seek an increase at the expense of what we now have. Living is getting more difficult with the increase of population. A short time ago I was present at the funeral of a person who had died possessed of an estate of three hundred acres valued at one hundred and twenty dollars an acre. All this he had entered as government land forty years before his death. Where now, I ask, can the young man get a farm? Where can he go as his father went, and fish on his own stream? Where can he cut down a tree for firewood without trespass? The land is no longer waiting for people to move in; for there is scarcely standing-room for those already there. Men are pressing one another, and many are going to the wall. Preservation and betterment of those we already have, not increase, is the crying need.

While humanity endures, the sexes will endure; and while the sexes endure, children will be born. But we should remember that a few well raised may honor our names; while many given over to poverty and crime is a disgrace to those who beget them, and to the country.

Nor is there any reason why the unwedded woman may not confer blessings on society equal to any conferred by her married sister. Indeed, there are many persons who in celibacy would lead the most altruistic lives. Many of us well remember when the state was almost unpeopled; whereas to-day clouds of smoke are everywhere seen rolling, where the axe and hammer used to be heard resounding through the woods. The same is true of almost the whole world, excepting a few uninhabitable regions.

The World's Population:

The number of people in the world is now given as 1,487,600,000. There are in the temperate zone 29,450,000 square miles of land; in the tropical zone 19,400,000; in the arctic regions 1,233,000—in full 50,033,000 square miles of land; in the antarctic regions there is no land worth mentioning. Considering the fact that not a little of this land is uninhabitable, consisting of vast mountains extending in some cases twenty thousand feet above sea level, and of regions perpetually covered with ice or snow, we have no doubt that 40,000,000 square miles would be a large estimate for the inhabitable land of the earth. In one square mile there are 987,983 circular surfaces each having a radius of three feet; and in 40,000,000 square miles there are of such surfaces 39,519,320,000,000. Suppose now we ask the question how long it would take the United States, provided it increases in the future as it has since 1790, to people the whole inhabitable globe so densely that it could put one person within every such circular surface. This country has increased on the average since 1790, at the rate of thirty-one per cent each ten years. The difference between the logarithm of 39,519,320,000,000 and that of 76,060,000 (the population of the United States at the last census) divided by the logarithm of 1.31, gives us 48.74. This means that in four hundred and eighty-seven years and five months from A. D. 1900, the United States could supply all the people necessary to put one person within every circle of six feet diameter on the surface of the whole inhabitable globe.

In 1890 the earth's population was 1,487,600,000; and in 1908 it was given by Mr. North as 1,672,937,531. Considering the rate of increase since 1908 as equal to that from 1890 to 1908, we shall have for the earth's population to-day (1914) about 1,734,951,144. The present density of population in the U. S. is 26 to the square mile. This is an increase of more than 5 fold the past 110 years.

Admitting the earth's population to-day (1914) to be, as given above, 1,734,951,144, and granting that its inhabitants increase every ten years about 10%, the population of the earth 500 years hence will be no less than 185,158,710,000. Thus: $1734951144\ (1.10)^{49} = x$; and Log. $1734951144 + 49$ Log. $(1.10) =$ Log. 11.267544. This gives us the natural number 185,158,710,000; which would make the density of the earth's inhabitants 4629 per square mile, and allow each person only 6023 square feet, or 77 feet square. At this or any other rate of increase there soon comes a time when there would not be room for a person to lie down, much less for every one to have a few feet of soil; and still much less would there be a possibility of the earth supplying such inhabitants with food. Whatever we may think, it remains a fact that the earth's capacity, however fecund she may be, is limited, finite; that a time soon comes when the human race would not if they could, and could not if they would, increase their numbers; if they did, then plague, pestilence, and famine would soon join hands against humanity to help rid the earth of its awful burden of pestilential life. We might well be thankful that we shall not be one of those who shall have to endure those days; and even to-day we might well consider if we have not a nobler work than to fill the earth with people, especially without thought or care. Men are not happier for living in a big city; nor is a country more blessed for having the greatest numbers: virtue, nobility, refinement, righteousness, these attributes depend not on size or numbers, but on quality. It is for this quality that woman should strive. She can best do this by first preparing herself to stand alone, and prove to the world that she is at all times and everywhere the equal of man. Then will she receive her rights, not because of the pity or mercy of the other sex, but because she will be able to enforce them.

No one can doubt that marriage is a good thing; but we frequently find persons who have found in it depths of woe rather than heights of bliss. It is for these unfortunate ones that divorce is a blessing. We know that some well-meaning persons oppose the granting of divorce; but these are either those who are unqualified to judge for the lack of personal experience in matrimonial relations, or those who are fortunate in marriage, but because of the lack of a broad and philosophic mind fail to appreciate the condition of those who have not been fortunate in their choice.

Men are driven precipitately by their passions, and to gratify them will run serious risks, and bear great financial burdens; and however threatening the laws may be, their secrecy and cunning generally enable them to gratify their desires.

It is because of this illicit gratification that at least seventy-five per cent of all men living in large cities suffer from sexual diseases, frequently entailing years of misery, and sometimes permanent injury, and that the great majority of all women in doctors' hands are there as the result of having married men who sometime or other have been thus diseased. No other of the higher animals is sexually so intemperate as Man, especially the male; and the ruin which results from it is everywhere present in locomotor ataxia, deformed bodies and minds, paralyzed nervous systems, forsaken homes, vagrant children, and blasted lives. We make these statements deliberately, and not hastily nor from hearsay: we write as we have known, seen and handled. From our professional relations with men and women we could write such burning words as should make parents tremble for the future of their daughter; but this is not our present duty.

As man should not by force of law nor custom be driven into matrimony, so should not woman. Furthermore, society should exact as much from the man as from the woman. But while the amours of the young man are winked at, and his chastity scarcely thought of; the young woman on the contrary is held to a very strict account, and mercilessly judged. This is just the reverse of the Thracian custom: "*τῶν δὲ δὴ ἄλλων θρηίκων . . . παρθένους μίσγεσθαι*" (Herodotus: Terpsichore 6); and we do not know for our part which custom is the better, but we do know that neither is good. What parents having given the greatest care in raising a daughter, and poured out infinite love upon her, can see their beloved leave the home of her childhood for that of the husband, without a feeling of intense anxiety? Was a change ever fraught with greater danger? How often she goes forth hopeful, buoyant, only soon to become despairing and broken. For her the glancing eye, the rosy cheek, the elastic step are memories of the past. Even though she regain a degree of health, she must remain the image only of the reality. But why mention these common events—events occurring every hour? Every one knows that it is woman who crowds the hospitals, and frequents the doctor's office. Even the medical student looks forward to woman as his hope for a livelihood. We do not exaggerate when we state that a large per cent of all women who go to the doctor, go as a result of their marriage—a marriage that should have been strictly forbidden or postponed by law. Who but a ruthless soul would force woman into such woes, and unparalleled suffering? Who may protect her? There is no law to punish the maker of all this evil, and custom even pities the "unfortunate husband." So I ask where shall woman's salvation be found? Is there any "balm in Gilead"?

Let woman cease to make it her one ambition to get a husband; let parents cease to knock their daughters down to the highest bidder. Let woman prepare herself, as man himself, for life's contest. Let her stand up in the dignity of her womanhood, proud of her exalted sex, and determined to stand alone, unless by the side of a man worthy of her.

Woman has done much for her sex, and to-day she is making her mark in every walk of life. Against the secret and the expressed, the active and the passive desires of man, she has, by the force woman has brought to bear on public sentiment, raised the age of consent throughout this country from that of childhood to that of reasonable womanhood. For thousands of years a female child of twelve was held legally sufficiently discreet to bear the full responsibility for the basest action of man in her relations with him—for a crime so great that the poet could write:

> "In qua ciuitate tandem te arbitrare uiuere?
> Virginem uitiasti, quam te non jus fuerat tangere.
> Iam id peccatum primum magnum." (Terence.)

Woman should also awaken public sentiment to the evil of dishonored motherhood; and should force such legislation as would be just to woman in her relations with the opposite sex. To-day she is far too unprotected. By every wile, by every oath, by the protestations of undying love, by means lawful and unlawful, even by the cup of lethe, man finally often gains his evil ends:

> "Persuasit nox amor uinum adulescentia:
> Humanumst. ubi scit factum, ad matrem uirginis
> Venit ipsus ultro lacrimans orans obsecrans
> Fidem dans, iurans se illum ducturum domum.
> Ignotumst, tacitumst, creditumst. Uirgo ex eo
> Compressu grauida factast." (Terence: Adelphoe 470.)

What now results? Disowned by her own, an object of derision and contempt, unable to stand the light of day, and no wish for the light of the moon, the unhappy one wraps about her forlorn self the black mantle of death, and lonely wends her way to the shades of Hades, a wretched, untimely ghost.

Woman has been in the past, and is to-day, raised up with the idea that she must belong to some man. Let woman emancipate herself; let her be her own redeemer, resolved on liberty or death.

We do not advise woman to despise the opposite sex. If she attempts this, she must and should fail. It takes the two sexes united to live one perfect life; but let her be in a position to give herself only when another equally worthy is given, and let each be free from disease and health-destroying germs. Then will the young woman change from girlhood to no less glorious womanhood, and woman's woes will largely end. But on herself depends her salvation. Neither male-law nor male-custom will save her, as the past has shown, to the shame of man.

Woman must cease to fall in love. I do not say, to *love;* I do say, to *fall in love.* In such a mental state all persons are ***non compotes mentis;*** and those who get into this state generally fall so far that they never rise again. Let woman love, and stand firmly while loving, judging critically, examining closely. Let her listen to the advice of a knowing father, or of men trustworthy, and unprejudiced. Let her decision be satisfactory to those who love her best with a love rooted in pure unselfishness. The basis of her judgment and of the judgment of those who love her, should not be wealth, nor even family connection. These things are good; but the qualities in a man, essential to a happy married life, are manliness, freedom from disease, diligence, integrity, and the ability to make a living for a possible family. These qualities being granted in the man who seeks a woman's heart, she need not hesitate.

Nor will she in such a marriage lose any of her dignity or nobleness; nor raise children as now for insane asylums and penitentiaries; nor fall any from the state of full equality with man. Rather will she be likely to add to her already glorious nature the everlasting dignity of wearing the crown of motherhood.

CHAPTER XXV

THE ORIGIN AND DEVELOPMENT OF RELIGIOUS IDEAS

NOTHING on "The Living Universe" could be complete which ignored the origin and development of religious ideas. We can not deny the fact of religion in the world, any more than that of the existence of the Mammalia; nor will any scientific mind doubt that the one is as much a natural product as the other. The intelligent mind fails at any time to witness any interference with the established laws of nature; nor can he have any faith in anything whose value depends on the setting aside of these laws. At all times and everywhere, and with everybody, the assertion of miracles is the admission of ignorance. In the body of nature there is no break, although as in our own there may be obscurity; and to us, children of a day, nature in her endless ages may appear to move slowly, but unlike ourselves she always moves surely. While having great regard for all, she has no special love for any; and the end of her activity is the perfection of what she brings forth. To this end the law of the survival of the fittest rules throughout the whole divine body. What is deemed most fit by us, is frequently not so much esteemed by her. The cell, molecule, organ, species, order, class, people, or nation which survives while others perish, certainly proves itself victorious in the struggle for existence; and this is all that is meant by the survival of the fittest. Nor have we any more right to complain of this than tissue debris at being devoured by phagocytes. We are but a cell of the molecule, humanity; of the organ, the earth;

of the body, the universe. If sufficiently magnified the organs of our bodies would appear millions of miles apart; and the mechanism, and the nature of the forces that unite them, and keep them intimately connected, would not be discerned by us. True we should invent some nomenclature to express what we saw, as now we speak of gravity, magnetism, electric disturbances, cohesion, storms and calms; but we would think of it all as dead matter ruled by law, and not as a living body. When Haeckel says: "When a stone is thrown into the air, and falls to earth according to definite laws, the phenomenon is neither more nor less than a mechanical manifestation of life than the perception of the formation of thought in man," we think that he is guilty of going to extremes, or of exaggerating a great truth. It is true we are but a little part of this great universe, but "one star differeth from another star in glory"; and we are willing to admit that the perception of the formation of thought in man, is a much greater sign of life than is the falling of a stone according to definite laws.

Nothing is more human than religion. Among all nations, kindreds, tongues; existing under every form of government; stronger than all political parties; older than organized society; man's solace in life and his hiding-place in death—religion remains to-day as ever the one common bond between humanity and God. None has ever lived so high as to think himself above it; and none has ever lived so low as not to try to reach it; none has ever lived so wise as not to seek wisdom from it. Such a force is well worth our highest consideration.

The force of religion is wrapt up in religious ideas. Our first duty, therefore, is to define what we mean by the word "religion," or the phrase "religious ideas." Cicero in De Natura Deorum says: "Qui autem omnia quae ad cultum deorum pertinent, diligenter retractant et tamquam relegunt, sunt dicti religiosi." (II. 28.) Those who carefully ponder over and as it were gather together again the things that pertain to the worship of the gods, are called religious. The Mundaki-Upanishad tells us there are two kinds of knowledge, the higher and the lower: the higher is the knowledge of Brahm, the Indestructible. (I Khanda.) And the great Aristotle tells us that theoretical philosophy is higher than positive, and that of all theoretical investigations the theological is the highest. (Meta. V. i. 10.)

It were impossible and unnecessary to mention every definition of religion; but should one seek such, traversing the ancient and modern world, confining himself at the same time to the words of the highest minds, he would find that it is, and has been, universally admitted that religion has three elements, God, man, and their relation; and religious ideas are those that arise in us concerning the Divine Being, our relation towards him, and in a lower sense towards our fellowman. This is what we mean by religious ideas. Nor do we imagine that a man ever lived who was without at least the beginning of these ideas; and we further are philosophically forced to believe that it is impossible in such a world as this, filled as it is with wonders on every hand, for an intellectual and well balanced man to be irreligious.

In analyzing religious ideas we find that they fall under two main classes:

Ideas Common and Accordant.

Ideas Special and Discordant.

Wonder, awe, reflection, law of causality, law of genesis, relation of the begotten to the begetter, relation of the ruler to the ruled,—these are the mental and physical forces that underlie the common ideas of religion. These causes are beneficent.

Conceit, ignorance, credulity, self-aggrandisement, inter-tribal and international strife, are the mental and physical forces that underlie the special and discordant ideas of religion. These causes are maleficent.

Aristotle, the greatest of all minds, tells us that it is through wonder men begin to philosophize, at first trying to unfold the more readily explicable, afterwards proceeding to the more difficult: The philosopher may therefore, be considered a wise fool; for he who wonders at things, finding himself at a loss to explain the phenomena, is called ignorant: "Διὰ γὰρ τὸ θαυμάζειν οἱ ἄνθρωποι καὶ νῦν καὶ πρῶτον ἤρξαντο φιλοσοφεῖν . . . καὶ περὶ τῶν μειζόνων . . . Διὸ καὶ φιλόμυθος ὁ φιλόσοφος." (Met. I. ii. 10, 11.)

Wonder is natural to all sentient existence. Not only in man, but throughout the whole tree of life is it manifested. But as man is the flower of this tree, so in man is wonder most active and efficient. Difference in quantity is not difference in quality. Man may be able fitly to discharge his duty as a member of the human family, but certainly no more faithfully than the cell as a member of the physiological unit. Even here all the phenomena of so-called life appear—digestion, assimilation, secretion, growth, decay, and death. The wonder of the philosopher is not that of the common scholar; that of the scholar not that of the ignorant, that of the ignorant not that of the beast; but in each and everyone wonder is inherent, and life is inseparable from it. Such a force must therefore be beneficent; and happy the man who possesses it to a high degree. Wonder grows in efficiency as life becomes more complex, until seated on its throne in the cerebrum of man, it arouses the purest thoughts and impels to the noblest inquisition that ever moves the soul of man. I have no need to specify the different causes of wonder. Plato has named many, Aristotle discussed some; and philosophers of every age and nation have admitted the value of these causes in the sphere of theoretical investigation; but we may say that in every art, in every science, in every attempt to unfold the book of nature, in every look at the heavens above or at the earth beneath, in the atom and the chemical molecule, in the unit of life and the aggregation of these units in the organic whole, in the forces and movements of the earth and the awful grandeur of the majestic system to which it belongs, in the lightning's flash and the peal of thunder, in growth and decay, in life and in death,—in each and all is found the constant cause of wonder.

Wherever wonder exists, there also flourishes a desire to fathom the mystery, or find the cause of the perplexing phenomena. Wonder thus gives early birth to the twins awe and reflection which lead man to yet deeper inquisition. Whereas the mother is rudimentary, the offspring is here complex. Could the average person behold the mighty run-away sun, Groombridge, coming towards us at the rate of 200 miles a second, he would likely be awe inspired; and when the philosopher beholds millions of suns attended by all their planetary cortege, moving in orbits which take them millions of years to complete; comets coming out of the boundless depths of space simply giving us a passing greeting, to disappear in the depths of eternity never again to come across our plenetary path; constellations of suns millions of miles apart, and millions of millions from us, moving with stupendous velocity in orbits so great as to make them appear almost, if not altogether, motionless; dead suns dashing heedlessly in their lifeless orbits awaiting re-birth by collision with other bodies, once more to take up the struggle for existence; system upon system throbbing with the pulse of life only in its turn to grow cold in the embrace of death; the protecting arms of father, and the dear caress of mother disappearing in the chambers of the tomb; his own boundless desires to solve the enigma of existence, and his longings for something higher and better, at the same time conscious of his ignorance and weakness,—knowledge of such things can not now fail, and never could have failed to awaken in such thinking soul the deepest sense of awe. Wherever awe exists there reflection naturally follows leading in its train thoughts on cause and effect and the necessary relation existing between them. The wondering soul of man seeks a cause for these phenomena, a cause sufficient to sustain as well as to produce them. As man evolves from a lower to a higher state he is able to grasp still higher relations, such as that between the begetter and the begotten. Says Aristotle: "The parent loves the child as being in a certain sense his own workmanship." (Eth. Meg. II. xii. 3.) Thus arises in man a sense of God's fatherhood; for he considers himself in some manner or other begotten of the Infinite Life he is and has always been trying to fathom. Of the universe he thinks as Cicero: "Mundo autem certe nihil est melius—It is certain that nothing can be more beautiful than the universe." (De Nat. Deor. II. 16.) He feels his close relationship to this wonderful whole, and can scarcely help concluding that he must be a child of the Father. He knows what it is to be ruled and to rule; and he soon infers a similar relation between what by some is called the dead universe and the mind that seems to pervade it. He knows himself to be a thinking entity; and feeling with Aristotle that the thing begotten is like the force that begets (Met. vi. 8.), he can not fail to infer a likeness to himself in the living force behind the phenomena he observes. Thus step by step from wonder, awe, reflection, law of causality, law of genesis, relation of the begetter to the begotten, and the relation of the ruler to the ruled,—he arrives at the common and consonant, and beneficent ideas which form the foundation of the world's religions. Whoever stands upon this foundation, will not fall: the winds may blow, the rains may descend, the tornado may demolish, but this foundation shall not be removed. It is founded in truth, and it is the well-spring of all that is best, noblest and dearest in the soul of man.

Of not a little religion is conceit and ignorance the origin. Man by nature thinks well of himself. This is proper. But when this thought of himself becomes exaggerated, a sense of his own importance possesses him. He claims pre-eminence among his fellows, certain peculiar rights and privileges, and finally divine sanction for his assumptions. In many cases through fear, ignorance, and weakness such special claims have been acknowledged. Sometimes such claimants have appealed to the divine powers in proof of their assumptions. In such cases upon the coincidence of certain unusual phenomena, ignorance has caused the doubter to yield assent to the demands of the claimant. We should remember this fact when reading the first chapter of the second book of Kings, where Elijah calls upon his god to consume the innocent soldiers and the captains who commanded them.

As a people or nation is only a multiple of the individual, what is true in this sense of the unit is true of the aggregation. Nation after nation has claimed special privileges with God, special favors from him, special knowledge concerning him. The Brahmin, the Buddhist, the Zarathustrian, the Jew, the Christian, the Mohammedan, the Mormon, all claim this special relationship to God, some more than others, but each to such an extent as makes it subversive of the claims of all the others. Each is a chosen people, to each has been made known the special will of God, and to each have been given his covenants and promises. Says Paul: "What advantage then hath the Jew, or what profit is there of circumcision? Much every way: chiefly because unto them were committed the oracles of God." (Rom. iii. 2.) Says the Christian: "Neither is there salvation in any other; for there is none other name under heaven given among men whereby we must be saved." (Acts iv. 12.) Says the Mohammedan: "We have had sent down unto us from heaven the book, the Koran, which contains everything that is necessary both as to faith and practice. Verily Mohammed erreth not, nor is he led astray; neither does he speak of his own will, but only what hath been revealed unto him. They are infidels who say God is Christ." (Koran:

ix. xix. xxi. liii.) Says the Brahmin: "The soul who is fixed upon the study of Brahm, enjoyeth pleasure without decline. There is not anything in this world compared with wisdom and purity. A man's own religion is better than that of another. It is good to die in one's own faith. I will now reveal unto thee a knowledge superior to all others. I am to be known by the Veds, the books of divine knowledge. The great Brahm is the womb. From it comes all nature. He my servant who serveth me alone with due attention, having overcome the influence of qualities, is formed to be absorbed in Brahm the Supreme Being." (Dial. Kreshna and Arjoon.) Says the Buddhist: "Buddha our Lord has revealed the truth. The body is conceived in sin and born in corrpution. At the birth of our Lord Buddha all the worlds were flooded with divine light. The blind received their sight; the deaf and dumb spoke; the crooked became straight; the lame walked; all persons were freed from their chains; and the fires of all the hells were extinguished. For seeking true religion there is never a time that is inopportune. Let us keep sacred and reverence the traditions. The word of Buddha shall remain forever. Let us take our refuge in the truth, let us take our refuge in Buddha. The truth is Buddha, and Buddha is the truth." Says the Egyptian: "Before all things that really exist, and before the beginning of time, there is one God immovable in the solitude of his greatness and unity. He is the Father and root of all intellectual forms. He is unity, entity, and essence, and the prince of all intelligence." (Jamblicus.) Says the Zoroastrian: "Man's soul will in some way or other clasp God unto itself. Having nothing mortal she drinks deeply of divinity. Seek paradise. Subject not the mind to the vast measures of the earth, for the plant of truth is not upon the earth. Fly thou these if thou intendest to open the sacred door of piety, where virtue, equity, and wisdom dwell in unity and peace."

Some of these extracts take us back to a time not less, probably, than 6000 years; and it is not at all improbable that could the grave of the past be opened similar teaching would be found occurring more than twenty thousand years ago. The thought of God is early domiciled in the heart of man as a result of the causes we have given; for as Aristotle says: "*Διότι πάσῃ θνητῇ φύσει γενόμενος ἀθεώρητος ἀπ' αὐτῶν τῶν ἔργων θεωρεῖται*—God although unseen to mortal eye is made manifest by his works." (De Mundo vi. 26.) It is not a mere matter of choice or will that we think of God: it is one of necessity; for by the very laws of our being we can not do other than seek the cause behind the phenomena of the inner and outer worlds. Step by step from the alpha to the omega of thought man proceeds from so-called nature to so-called God; and to this end there is neither place nor need for miracle or revelation. The problem is a natural one, and the power to solve it is equally natural, and the solution when obtained is wholly so.

Man should never seek a god to do the work of a mouse, never seek a miracle to explain a well-known fact of experience. There is nothing strange, therefore, in the excerpts we have given, nothing peculiar. All nations, all peoples, all religions make similar claims, and assume similar authority. In so far as any of them assume to be the only authority, or demand exclusive recognition, we may be sure that such assumption or demand is founded on one or more of the maleficent causes mentioned, and not in truth nor nature. Such assumptions would speedily die as a bacillus in a healthy organism, were it not for the fact that there are so many forces interested in sustaining what has been falsely assumed. Power, prestige, authority, position, income, and ease, all or any of these drive men to keep what they possess, and add to it if they can. Says Brahmanism: "Although a king is exalted, he must sit at the feast below the Brahman priest"; and said the Puritan Cartwright:

"The magistrates must remember to submit themselves unto the church, yea to lick the dust off its feet." And Moses in fear of constant rebellion, after giving his people a name for their national god, and hiding himself in the mountain for a season, could come down with alleged proofs of a conversation with God; and although his anger and breaking of the tablets, should at any time evoke suspicion of their genuineness even in the breast of the little scientific, yet ignorance and credulity so obscured the minds of his followers that the love of aggrandizement, popularity, and power which lay behind the work of Moses, remained securely hidden in his own prolific mind.

Intertribal and international strife have also worked to originate religious ideas. In all ages have the priests called upon their gods to fight their battles. Says Herodotus: "And thus all were drawn up according to their nationalities. On the second day both sides sacrificed. Tisámenos the son of Antíochus was the priest that accompanied the Greeks, and for them he offered sacrifices." (II. ix. 33.) In the Old Testament we read: "And they cried to God in the battle, and he was entreated of them, because they put their trust in him." (I Chr. v. 20.) And says the book of Joshua: "And Joshua the son of Nun called the priests, and said unto them Take up the ark of the covenant, and let seven priests bear seven trumpets of rams' horns before the ark of the Lord. . . . And it came to pass on the seventh day when the priests blew with their trumpets, Joshua said unto the people, Shout, for the Lord hath given you the city." In this battle the harlot Rahab, we are told, was the only person spared. We refer to past ages, but the forces so productive of evil in those days are not without power to-day. Our own president could call on the people of the land to give thanks unto God for victory over the Spaniards; and perhaps every modern nation prays for victory over its enemies, and returns thanks to their god of battles for victory over the fallen. Nor is the priest slow to use his office under these circumstances. In such days of peril, when fear and trembling seize hold of man, he is prone to look for refuge anywhere. To the dying the priest offers salvation, to him in danger special protection; and his prayers and sacrifices go up for the sake of his countrymen engaged in bloody strife. It is to the interest of every priest of every shade and color to lay stress on the importance of his calling; and this in general he is never slow in doing. Thus step by step through conceit, ignorance, credulity, self-aggrandizement, intertribal and international strife, has man come into the possession of those religious ideas that are everywhere discordant and maleficent. And as the heart of man expands in sympathy for his brother, his eyes open to behold God in nature, and his soul grows in his conception of the Infinite Father, he becomes more and more conscious of the baneful character of these causes, which ever work against the uplifting of man, and the enlightenment of the world.

About 500 years B. C. Herodotus in speaking of the Arabians said: "τὸν κύκλον πάντα τοῦ οὐρανοῦ Δία καλοῦντες—I know they do not build temples nor altars, nor images. Indeed, they regard those as foolish who do these things. They do not anthropomorphize the deity, but they call the whole heavens God." Anaxagoras (500 B. C.) held that no matter what their relative power or station, all minds are in quality alike; that mind is the most etherial of all existences, and that God is the soul of the world. Xenophanes (569 B. C.) says that while there is but one God, all men seem to make their own divinities. "God," he says, "is all eye, all ear, all intellect, the mind and unity of the world." Socrates (469 B. C.) maintained that God is the wisdom that is present and rules in all things. Aristotle (B. C. 384) holds that God is the pure actuality, the self-thinking reason or absolute spirit. The Stoics held that spirit is the highest force embodied in substance, that God is the consciousness of the universe, and that man's soul emanates from the deity.

Being thus made in the divine image, it is not strange that we should be trying to trace God's footsteps in the sands of time, and interpret his will concerning us. There is a truth, therefore, in all revelations, in all religions, in all prayers, in all sacrifices, in every pealing anthem, in every tolling bell; but with this truth there is mixed much that is false.

In considering the very many world-wide and world-affecting religions one can not plead on the ground of the survival of the fittest the superior excellence of his own peculiar faith simply because it happens to have been developed in his own land, or to be the religion of his country. When one's present faith is considered with reference to the many forms his own people have some time or other followed in the ages gone by, it would be philosophical to affirm its probably superior excellence from the fact that, in the contest for supremacy with other once existing forms, it has survived, while the others have passed away; but such argument is not applicable with reference to exogenous forms of faith, or to those forms which have been similarly developed in other lands among other people. Before such argument can be applied natural selection must be possible, and this requires very much time; and that the faith may be a surviving one there must be a struggle among the various competitors, and this requires their contemporaneous existence in the same locality or country. It is only during comparatively recent times that world-wide religions have left their birth-place for foreign lands for the purpose of ousting the native faith, and displacing it in the affections of the people. That the survival of the fittest may be possible in such case, the people must be free from all restraint legal, moral, and social; the new or exogenous faith must be perfectly free to influence the people, and the people must be perfectly free to choose. At the present time this contest is going on to some slight extent; and in the future it must broaden, deepen, and intensify as all barriers against commerce and travel be removed, and complete rivalry on the same ground be possible among the leaders of the various world-wide religions, and unrestricted freedom of speech and social intercourse among the adherents of the different faiths. This time is coming; and the distant future will see all world-wide religions very much changed. Some will pass away in the struggle (Earth acts thus with all her progeny), others will survive; but as in the case of surviving animals and plants, none will come out of the contest as it entered it: the surviving form or forms will have cast off this or that useless organ, and produced others as shall have adapted them to their changed condition.

The universal religion at present most conquering is Christianity; and of this faith we will now give the essence, or the most vital element.

Should one be asked what is the most essential element of government, he might correctly enough answer, obedience to authority. But such obedience we find everywhere, under every form of government, whether that of the Czar, the Kaiser, the Sultan or a king. As obedience to constituted authority is an essential element of every form of government, so of a hundred forms no two may be alike, and all may condemn one another. Obedience to constituted authority is an essential element of government among all English-speaking people; but among these people are found also certain inalienable rights and liberties which distinguish their governments from that of all other peoples. If an Englishman were asked what is the essential element of his government, he might properly answer, "the Bill of Rights, and the Magna Charta." To a similar question a native of the United States might reply: "the fact that I can be president of the United States"; whereas a native Russian might answer, "that I serve the Czar alone." But the truth of their different replies would be no proof that they believed in one another's government, although obedience to rule is an essential element of each. It is thus in religion. Certain elements are common to all; some others held by all in part; others held exclusively by the peoples who recognize such exclusive forms. The differentiation is not found in the common element or elements whether in government or religion, but in the factor or factors exclusively held by this form or that; and in the definition, whether of a religion or government, the differentiating factor or factors must be mentioned as the essential or most vital element of such definition.

In discussing the question what is the most vital element of Christianity, one is warranted in holding that could he discover the element which gave Christianity birth, and which more than all other elements distinguishes it from the many other faiths of the ages past and present, he might rightly affirm that he had discovered the most vital element of Christianity. Sir Oliver Lodge was quoted in 1906, in the Hibbert Journal, of London, as saying: "The conception of a human God, a God not apart from the universe, nor outside of it, but immanent in it, actually incarnate, and revealed in the incarnation, this I take to be the most vital element of Christianity." What does Sir Oliver mean by a "human God"? He certainly can not mean a god conditioned as man, or limited in the sense we acknowledge ourselves to be; for such were no God. He must mean a God characterized by the sum total of the high and exalted qualities which men affirm are possessed by the Supreme Being; that is, a God in a logical sense, the offspring of the best thoughts of the best men. If he means this, such a conception is certainly not the vital element of Christianity; because God can not be and never was thought of by man except under human conceptions. Thus in a certain sense God must be a human God, a human production. But this is true of all religions and is not peculiar to Christianity. Nor is Sir Oliver any less wrong when he affirms that the conception of God as incarnate, and as immanent in the universe, is the vital element of the Christian faith. In the Bhagvat-geeta we find God thus characterizing himself: "Behold my body, the whole universe animate and inanimate. When thou beholdest all the different forms of nature comprehended in one alone, and so from it spread forth into their vast variety, thou conceivest Brahm, the supreme spirit, who is within the midst of the universe, and possesseth the vast whole—Brahm, infinite in power and glory, who includeth all things, and is all things. I am generation and dissolution, the place where all things are reposited, and the source of all nature. I am in the ox and in the elephant; in the dog, and in him who eateth the flesh of dogs. Fools torment the spirit that is in the body; and myself also who is in them." Here we have given us in the highest Brahminical writings the essential element of Brahminism—the unity of God and the universe, the divine immanence and incarnation. In Brahmanism God is not outside nor apart from the universe; for every element of the vast whole is an essential part of the Divine Being. God is the universal substance which is neither matter nor mind, but the undiscoverable and inexpressible essence out of which matter and mind flow. God, Brahm, is the universal womb, which is ever giving birth to the visible universe. This great Self we can not sensuously come near; but as out of this womb nature comes forth, we behold the infinite one, as it were, unfolding himself. Forms come and go with time; but the substance remains forever unchanged and unchangeable, and back to this substance must every created thing return. This Brahm is incarnate, not only in man, but in all created things. Thus we find that while Sir Oliver Lodge's definition of the central element of Christianity is totally inapplicable to the Christian faith, it is quite fairly expressive of the central element of Brahmanism; for take away the thought of God's immanence in nature, his unity with the universe, and his incarnation, and Brahmanism has nothing around which to revolve. In speaking of God the Upanishads say: "Him you see in the earth, in heaven, in the air, in the ether, in the water, in the moon, in the stars, in all beings. He alone is Brahm—the light of the world, and the same light which is in man." In the Bhagvat-geeta we read: "Although I am not in my nature subject to birth or decay, yet I am made evident by my own power; and as often as there is a decline of virtue, and an insurrection of vice and injustice in the world, I make myself evident. Thus I appear from age to age for the establishment of virtue." Here we have stated in the most authoritative manner from the most authoritative source the essentials of Brahmanism—namely, not only the divine immanence and incarnation; but also the essential unity of God and the universe. If these essential elements of Brahmanism are, as Sir Oliver Lodge asserted, the one vital element of Christianity, then should we call it Brahmanism, or reformed Brahmanism, and not label the Christian's faith Christianity. Sir Oliver was fundamentally wrong. Christianity is not what man may make it, or wish it to be; but it is what it is, whatever that may be. It certainly is not discoverable in the definition of Sir Oliver Lodge.

If one ask what is the essential element of Mohammedanism, we answer: "There is no God but God, and Mohammed is his greatest prophet." This assertion or belief is distinctive of Mohammedanism; because while it is denied by every other religion, it is around this central element that Mohammedanism revolves. In like manner if we can find the central point or force around which Christianity revolves, whose existence or truth is denied by all other faiths, we shall certainly be able to state what is the most vital element of the Christian faith.

"God so loved the world that he gave his only begotten son that whosoever believeth in him should not perish but have everlasting life. For the Father judgeth no man, but hath committed all judgment unto the son, that all should honor the son even as they honor the Father." (St. John.) "God commendeth his love towards us in that while we were yet sinners, Christ died for us. He spared not his own son but delivered him up for us all." (St. Paul.) "In this was manifested the love of God towards us because that God sent his only-begotten son into the world that we might live through him. Herein is love, not that we loved God, but that he loved us, and sent his son to be the propitiation for our sins." (1 John IV.) "If thou shalt confess with thy mouth the Lord Jesus, and shalt believe in thine heart that God hath raised him from the dead, thou shalt be saved." (Paul.)

"Therefore let all the house of Israel know that God hath made that same Jesus, whom ye have crucified, both Lord and Christ." (Acts.) "For we see Jesus who was made a little lower than the angels for the suffering of death, crowned with glory and honor; that he by the grace of God should taste death for every man. God hath in these last days spoken unto us by his son, whom he hath appointed heir of all things, and by whom also he made the worlds, who being the brightness of his glory, and the express image of his person, when he had by himself purged our sins, sat down on the right hand of the Majesty on high. Once in the end of the world he hath appeared that he might put away sins by the sacrifice of himself. God laid upon him the iniquity of us all, and made him to be sin for us who knew no sin; whom God hath set forth to be a propitiation through faith in his blood." (Paul.) "As the Father knoweth me, even so I know the Father." (St. John.) "Which he wrought in Christ when he raised him from the dead, and set him at his own right hand far above all principalities and powers and might and dominion, and every name that is named not only in this world but in that which is to come; and hath put all things under his feet, and given him to be the head over all things in the church." (Paul.) "Behold a virgin shall conceive and bring forth a son . . . . And Joseph knew her not until she had brought forth her first-born son; and he called his name Jesus." (Matthew.)

In these quotations may we find the essential elements of Christianity, and therefore the most vital elements of the Christian's faith.

It is now twenty-one years ago that I was deposed from the priesthood of the Episcopal church by Bishop Tuttle, in St. Louis, Missouri. For denying the truth of several of these quotations, I was charged with heresy; and when so accused by my bishop and others, believing that my position was right, I demanded deposition. After all these years, thinking much over the past, present and future, my duty to myself and others, I find no reason for blaming myself or my bishop. I believed and believe that I was right; I believe the bishop also was right. It is not a question whether the Christian faith is true or not that is open for discussion by the priest ordained to officiate at the altar of the church. The truth of that faith is admitted once for all at his ordination; and on this admission he is entrusted with the sacred mysteries of Christianity. He is ordained as the servant or agent of the church, and to labor as his master or principal, the church, may direct. He has no right to tell his hearers what he thinks or believes should be regarded as truth. His mission is to declare the truth as the church has set it forth; and when he can not conscientiously do this, his duty as a man is to leave the church, and not as a coward to thrust a poniard into her back. It is cowardly for a man ordained to officiate at the altars of the church, to take advantage of his position to tear her vitals out; and it is unmanly in him to have his bread buttered by the church whose foundation he repudiates.

We do not condemn the man who honestly can not accept the fundamentals of the Christian faith. We believe that a man may be most virtuous and most religious and yet refuse to accept some of these principles. But it ill becomes a minister, remaining in the church, to reject an interpretation universally given, or to give to a word a meaning the church has always refused. It is amazing how a man may play with words and phrases, as a child with soap-bubbles; and how readily he imagines he has found something new, although ten-thousand years old. It is thus with Sir Oliver Lodge. Nothing in his article is new, nothing " astounding," nothing " extraordinary." Every word, every phrase, every thought, occurs over and over in the pages of the Eastern religions; and these ideas are not, as he imagines, found in excess in Christianity. They are peculiarly Brahmanistic, pantheistic; and have always been condemned by the Church, when brought forward as the vital element of the faith.

It would have been better had Sir Oliver Lodge confined himself to his scientific work; but if he meant what, in the article referred to, it is asserted he said, he should quit the Anglican communion, since his article is condemned by all her confessions, and all her creeds. I would also advise a minister not to seek passage on a vessel whose builders and makers he condemns. It is more manly for such to get aboard a tug-boat, or even to try to float on a raft. We admire a brave enemy; but have only contempt for the man who, while he offers his hand, keeps his heart far away; who while pretending to believe in the church at whose altars he serves, remains there only for the sake of his salary or position.

While the thoroughly educated and philosophic mind must find himself unable to accept many of the fundamentals of the Christian faith, he knows the history of the church, acknowledges the good she has accomplished, and admires the man who lives and preaches consistently with the faith he promised, in his ordination, to uphold; or who when he finds himself unable to believe it any longer, leaves the church that gave him his ministerial authority, and seeks his bread elsewhere, even though he is finally forced to herd with goats.

The most vital element of Christianity (we do not say, mind you, of religion) is plainly given in the quotations above; also very logically and clearly set forth in the Apostles' and Nicene Creeds, the great symbols of Christianity. This most vital element of Christianity includes, among many other principles, the immaculate conception of Jesus Christ; his divine nature, perfect man, perfect God; his divine incarnation; his atoning sacrifice; his resurrection from the dead — these are principles of the Christian Church; and as these are declared to be the peculiar and distinctive elements of Christianity, so is their truth denied by all other religions past and present.

Of all the progeny of Earth, I believe we are right in saying that Man is the highest, and that of all the attributes of Man that the religious is the most exalted. Nor in our considerations of the Living Universe must we forget the fact that religion is here; and that in the struggle for existence, as far as that struggle has yet been possible, Christianity has outstripped its competitors in the minds and hearts of the most enlightened nations of the world. This we are bound to acknowledge; and therefore it is very proper that the thoughtful man should be able to give a reason for the faith that is in him by being able to state the most essential elements of the Christian faith, as well as the causes and factors that have made it seemingly the foremost religion of the world.

CHAPTER XXVI

LIFE, REASON, CONSCIOUSNESS

CHEMICAL affinity is that force in substance which brings and holds together what under general conditions are considered the indivisible elements of matter or atoms. In most cases such combinations are made at the expense of others previously existing: that is, there is dissolution of some existing combination, and a formation of a new one out of the atoms that had existed in the old. All chemical changes taking place in nature are the result of chemical affinity.

The minutest portion possible, in a free state, of substance is called a molecule. Every molecule is composed of two or more atoms, which are believed never to part company, unless as a result of great violence, and to move freely about as a united whole, no matter how much they are disturbed or agitated, provided the general conditions are such as make possible the existence of such molecule.

Cohesion is that force which binds and holds together the different molecules which enter into the formation of any substance.

The cell is a vast number of molecules attracted by common characteristics, appetencies, and motives. It is the fundamental unit of all organic structure.

In a secondary sense the unit of organic structure may be called a physiological one, composed of a vast number of cells attracted by common characteristics, appetencies, and motives.

The organ is a vast number of physiological units attracted by common characteristics.

The body is a number of organs brought and held together by elements similar in character, unified by common appetencies and qualities, and preserved by the combined effort of the different organs moved by motives towards a common end, which is generally synonymous with self-preservation.

The law of the animal and of the vegetable economy begins in the molecule, and becomes broader and deeper as life becomes more complicated. The adult tiger is no more alive nor conscious than its fœtal germ was in the mother; but whereas the one is alive and conscious as a tiger, the other is alive and conscious only as a fecundated ovum. Life and consciousness are relatively no greater in the one case than in the other. Voluntary effort and the consciousness of such effort grow *pari passu* with the complicated nature of the individual. The actions of the hydrogen and the oxygen atoms forming the molecule of water prove that they are no less conscious than those forming the molecule of starch; but while the molecule formed in the former case is most elementary, in the latter case it is most complex. Carbonate of lead is a very stable because simple union of homogeneous bodies, whereas the animal or vegetable cell is a most unstable because extremely complex union of heterogeneous bodies, all having a most complicated composition; and in the latter voluntary and conscious effort is immeasurably greater than in the lead carbonate, as its manifestation is greater in taking a ship-load of merchandise across the sea than in drawing water from a well. But the evidence of reason and consciousness is relatively as great in the one case as in the other. Life in the atom is no less certain than in the molecule; but less evident, as the grain of sand on the sidewalk would be less evident than the massive conglomerate boulder. Life is no less certain in the molecule of sulphuric acid than in the molecule of starch; but less evident, as life is less evident in the bacillus diphtheriæ than in the filaria nocturna. Life is no less certain in cuprum sulphate or in the diamond than in man; but less evident, as the garrison asleep is less evident than when attacking the enemy. All atoms are alive and thinking, because they could not be dead or unthinking, being formed out of the living plasma of the eternally living and conscious Universe.

Molecular health depends on the harmonious motions of the atoms; the health of the vegetable or the animal depends on the harmonious motions of the physiological units composing their bodies.

Wherever there is unity each part is found working with reference to every other part; and wherever each part is found thus working, unity may surely be inferred. If a woman fails in her gestation five or six months after conception, lactation sets in as if a child had been truly and naturally born. The organ of gestation and that of lactation are related as parts of a unity; and the latter's duty being to take care of whatever the former proffers, it makes preparation for its coming to the breast, not being able to conceive of the failure of nature. So in the greater cosmos, as far as the mind of man can fathom, each part of the universe is related to every other; and the well-being of each part is dependent on that of the whole. The philosopher is as truly forced to recognize the unity of the universe, as the physiologist an organic unity, when he sees such relations as we have mentioned above between the organ of gestation and that of lactation.

In cell-division we have first the nucleus of quite regular form embedded in the cell-protoplasm; next there is an increase of chromatin, and the beginning of ray-formation; next a grouping of the rays as it were, making them fewer and larger; then appears the completed star; next this star assumes an ellipsoid form; next a division begins through the long diameter; next appear as the result of this division, two imperfect stars, which move apart from each other until they form the poles of the protoplasmic mass; next a constriction sets in between the two poles; finally the mass breaks into two at the constriction, and the two stars now appear as two complete nuclei instead of the original one. But so great is the unity of all these cellular forces that the principal photoplasmic mass does not divide at the constriction until the daughter-stars have assumed the ordinary nuclear structures — in other words, are able themselves to do a mother's work. It is impossible not to recognize intelligence and purpose in the successive stages of such cell-division, and a regulation or direction of all the cell-activities with reference to the development of the whole in accordance with a preconceived plan. So with reference to the Flagellates, it seems impossible not to see purpose in the peculiar actions of the male when approaching the female; nor any less is there reason exhibited by the phagocytes of the blood when destroying a common enemy, or ridding the blood-current of a noxious trespasser. From a molecule of hydrogen atoms through the whole range of being, whether it be in the least and simplest expression of existence, or in the universal whole, the philosopher is forced to admit that one kind of force pervades each and all — the force of reason and mind; and since it is impossible to conceive of a regulator infinitely removed from the thing regulated, especially when the regulated and the regulator must be of the one and same essence, he is forced to admit that substance itself, however small or mean, is rational — that it always acts according to its own reason, which even in the highest finite intelligence is only borrowed from the one Universal Consciousness.

We often use the word existence. We must not forget that real being is not truly cognized by our senses. What we see or feel is only phenomena as weight, form, heat, coldness, resistance. These are truly only attributes or qualities; and the ideas evolved in us concerning the substance back of these qualities do not result immediately from it, but mediately or through a correlation existing between us and the outer world. Hot and cold are truly said not of the substance itself, but only of the sensation produced through the interaction of such substance and our faculties. So of any other quality or attribute — they are qualities and attributes only as interpreted by us through the medium of sensation. It is only the expression of existence, and not existence itself, of which we are conscious. What we see, feel, or hear is only a result of two factors, real substance itself and our faculties, producing a result, as when two bodies coming together produce heat or light or sound, as manifested through our own senses; and on this compound result is based all our knowledge of the outer world of being. This may be abstruse; but we are too much given to the consideration of matter as being common or gross.

We easily hear the heavy drops of rain as they fall on us, while the rolling thunders peal from horizon to horizon; but we fail to be conscious of the falling dew-drops, even though our garments tell the tale that we have been exposed to a moisture-laden atmosphere. We may fail to recognize a most delicately shaded voice when rendering in softest accents a soul-stirring musical composition; but the noise of martial music readily attracts our attention. We turn our face to the sun, and the painful sensation of the fierce solar rays entering the eye leaves us no room for doubt whether there is light; but the light from Sirius alone may keep on falling, even while we say "'a little sleep, a little slumber'; it is yet darkest night." A person with normal vision can select any of the differently colored skeins of Holmgren's wool as he may be directed; but the patient with total color-blindness will confuse them all. If he has partial color-blindness, he will fail to match the color as to which he is blind. If he has red-green blindness, and is asked to match the purple skein, he will select for this purpose a blue one, which shows he fails to recognize the red in the green.

The normal eye protects itself from too strong light by contracting the pupil, and aids its vision in dim light by expanding it; but in certain pathological conditions such as Argyll-Robertson's pupil the eye fails to make use of the fibres for this purpose. It is to this extent paralyzed, and can not therefore act as a normal eye. Such a state is frequently seen in locomotor ataxia. We learn from these facts that notwithstanding one does not feel the drop, the moisture may be there; that though one does not hear the sound, the sound may yet be there; that though one does not see the light, the light may still be there; that though one does not see the color, the color may be there; that though neither the circular nor the radiating fibres of the iris contract because of paralysis of these portions of the motor oculi and sympathetic nerves, the pupil is still there.

The superficial area of the body of a man of middle size is about 16 square feet. The atmospheric pressure on such a body can not be less than 35560 lbs., or about 16 tons; yet we are not conscious of this pressure. At ordinary atmospheric pressure at a temperature of 16°F., 100 cubic inches of dry air weighs 31 grains; nevertheless none of us ever perceives this fact. In the most perfect vacua obtainable through absorption of the residual gas with red-hot charcoal, after mechanical exhaustion of the air, a pressure of only 1/350th of a millimetre has been reached; and Crookes obtained through chemical means a vacuum of only 1/26000th of a millimetre. Notwithstanding this great rarification some gaseous pressure remained; for in fact it is theoretically impossible to make an absolute vacuum; for the volume of air extracted at each stroke of the piston can be only a fractional part of the whole in the receiver, and this rarification can be kept up only so long as the elastic force of the air left in the receiver can overcome the pressure of the valve on the inside of the piston. So there is some gas left however much the sense may fail to detect it. One hundred cubic inches of hydrogen weigh only 2.14 grains, while a similar volume of uranium weighs 511.46 grains. Yet no one denies the existence of the hydrogen by affirming that it has no mass at all.

If water be poured on sand, it immediately disappears; but poured into a basin of clay or gold, it remains. Shall we therefore say that in the former case the sand is porous, and the clay and gold not? Put some water inside a solid ball of gold, and subject the ball to great pressure. Water will be seen to ooze through. This proves the porosity of the gold. Thus the difference in porosity is one of degree not of kind.

The truth is that all our knowledge is limited to matters between two extremes, the infinitely little and the infinitely great, to comprehend either of which we are absolutely powerless; but we are equally unable to deny that the extremes are there. In all such and similar matters ignorance is the cause of erroneous conclusions. As knowledge increases, the sphere of the miraculous lessens; and when knowledge becomes perfect, the sphere of the miraculous is contracted to a point — in other words, is not.

In the ninth century ergotism was a scourge in France; and the records of the annals of the convent of Zanten, on the Rhine, show that the people flocked to the churches to be relieved miraculously of their suffering from the "holy fire." It is said that 40,000 died in Acquitaine, Limousin, Pirigord, and Angoumois, although the clergy were enriched for their vain intercessions. The relics of St. Martial were carried in procession by the bishop, and the plague is said to have been stayed. About the year 1100 the sufferers from St. Anthony's fire implored divine mercy before St. Anthony's relics. Thousands flocked to the church of La Motte of St. Didier; for it was believed that if those suffering could remain one week, they would be cured. Even in 1762 chroniclers wrote about the thousands who had flocked there, hoping for salvation. One chronicler says: "We can still see in this abbey dried and blanched limbs kept from that time." In those days the sufferers and even the clergy referred the scourge to God's displeasure, although it is now known to have been the results of ergotism.

Rabelais alluding to St. Anthony's fire at the end of his introduction to book 2nd of his works, offers terrible imprecations against those who might question the truth of what he wrote: "May St. Anthony's fire burn you, mauditerre return to you, Lancey and malubec afflict you; may you get caquesangue and ricqueracque, fire as fine as cow hair with quicksilver in the foundation; and as Sodom and Gomorrah may you fall into sulphur and fire, and into the depth if you do not firmly believe all I want to relate in this present chronicle." Belief in miracles at one time was universal; and though the clergy are ashamed to-day to teach it, many persons are yet given to think that God interposes himself when and where he wills in the works of nature. As in the animal and vegetable kingdoms God is not found working in nature, and suddenly interrupting its order by special creation, but rather manifesting his presence in what are termed natural law and natural order, so in the universe at large, in all its separate parts we have but modifications of some less differentiated form; and could we go back far enough along the line of derived existence, we should finally find ourselves in the unity out of which all the myriad forms that are, have been evolved.

All various elements are but modifications of the one universal substance or force; all compounds are but slightly different arrangements of a few common atoms, which themselves have been generated out of the one common substance; all the various scenery that beautifies the world, is but the natural result of the same universal forces which are everywhere modified in their action more or less by physical conditions; every cosmological system is but a natural result of evolution working in a universal and undifferentiated world-substance; and every planet and satellite are but the natural result of similar forces working in the parent star or sun. As we do not find any scientific reason for believing in divine interposition for the explanation of the different varieties of the horse, dog or bird; so do we find none for such belief in explaining the origin of the different varieties of worlds that roll through a common space. Man's faith in the miraculous disappears *pari passu* with the growth of his scientific knowledge. For hundreds of years science was founded on faith. At length the whole temple fell; and it is not likely that it will ever again be founded on sand. Faith is good enough for matters of faith — that is for matters whose reality can never be determined; but it certainly has no place, and should have none, in matters of science. As there is no place in geometry for loose talking, so is there none for faith where scientific data are obtainable; faith is one thing, and knowledge is another. Let me not be understood, however, as saying that there is no place in man for faith; we know differently: were there no place in man for faith, there would be none in him; but we know that man is more or less religious. In scientific thought, however, where faith enters, there science flees.

By some it is believed that the origin of life can be explained only on the assumption of a direct creative act; but we affirm that all the possibilities of life are in nature. Given the conditions, life will manifest itself in all its varied forms. Such conditions were present in past ages more than in these days. It is most unreasonable to postulate any other agency in the heavens than that of the universe itself, in assigning a cause for any of Earth's evolved offspring. If in organic beings, there were any peculiar substance, anything not found in the rest of nature, it might appear reasonable to infer a peculiar or special origin for them; but there is no substance found in them which is not found in so-called dead matter. Nature gives us no special organic elements, and no simple organic substances. Organic matter differs from inorganic matter only in its manner of combination. Haeckel very properly says: "We are not able to distinguish any essential difference between these two groups of bodies. The origin of the first Monera by spontaneous generation appears to us as a simple and necessary event in the process of the development of the earth. If we assume the hypothesis of spontaneous generation for the origin of the first organisms, we arrive at the establishment of an uninterrupted natural connection between the development of the earth and the organisms produced upon it, and in the last remaining place of obscurity we can proclaim the unity of Nature, and the unity of her laws and development."

It will hardly be questioned that the various branches, classes, orders, genera, species, etc., are results of natural law. How varieties are produced by man we all know more or less perfectly. Sir John Sebright, one of the most experienced pigeon-breeders of England, asserts that in three years he can produce any kind of feather wanted; and in six, any form of beak or head. Darwin has proved conclusively enough that all the varieties of pigeons have descended from the one species, the blue-rock pigeon. How varieties of flowers and vegetables may be produced, we all have more or less evidence every time we enter a green-house. The different varieties of cattle, horses, sheep, fowls, birds, etc., are living witnesses how much the hand of man can accomplish in modifying the forms of the living things around us. But without the hand of man, even in their own wild state, every organism is subject to change. It is nearly impossible to find two living things of the same variety exactly alike. This cause of variation lies first in the germ; secondly, in everything by which the growth of the organism is affected, such as soil, food, climate, and geological differences. Watch the growth of the pine. After you have passed north to a certain latitude, or have entered a certain temperature, you find it becomes stunted and dwarfed all over the world. Again, as you go south, you find vegetation of all kinds becoming more and more rank; until having entered the tropical forests, you are amazed at the richness, vastness, and endless variety of the vegetation surrounding, under, and above you. On a mountain-side one may observe the effects of climate on plants. At the bottom you may have cattle grazing, and stately trees with beautiful and luxuriant foliage; but as you ascend, your cattle will refuse to follow you, the grass will turn backward, the trees will lose their rich foliage and their deep greenness; and grieving for the place they have left, will finally sicken and die. At length you have only moss or some such low vegetable for your companion, all other kinds of vegetation having found it impossible to live at such an altitude. Modification went on until the same variety could modify itself no more without destruction; and as it was compelled to modify itself or die, it was forced to die.

The truth is that no vegetable nor animal is in reality fixed. However much the same stock be kept to itself, the descendants will be more or less modified; and this is because it is impossible for the germ to be exactly alike in every case, or perhaps in any two cases, or for two plants or animals to be exactly alike affected by similar physical conditions, or for exactly similar physical conditions to condition the growth of two organisms. Living organisms are affected by internal and external forces. The internal forces are the peculiarities of the organism; the external forces are the physical forces and conditions that surround it. The former forces may be said to act upon the organism indirectly; the latter, directly. The term used to express the former by Darwin, is natural selection; by Spencer, the survival of the fittest. Natural selection or the survival of the fittest has probably a greater influence in changing species than the physical forces which act upon the organism directly; yet all work together, and between them accomplish the grand results we witness in the world.

It is certain that no scientific reason can be given for the belief that classes or branches or kingdoms were original acts of creation, while the different varieties are the results of art or of natural law. Wherever we see a variation begun, there certainly we behold the beginning of a new species.

What man can accomplish in a few years, that we may be sure nature can in millions; for whatever is in man comes out of nature. Such transformation brought about by nature, we can never really witness, as we can not see the tree or the flower grow; and yet we know the tree and the flower grow. So also may we be certain that these transformations, although unseen to us, are going on every moment in the laboratory of nature. The many varieties are but modifications, more or less stable, of the one species; the many species are but modifications, more or less stable, of the one genus; the many genera are but modifications of the one order; the many orders are but modifications of the one class; the many classes, but modifications of the one branch; the many branches, but modifications of the one kingdom; and even the different kingdoms can be but modifications of the one common form; and this common form is but a modification of the one infinite, eternal, and universal, Conscious Substance, God.

Special creation is utterly without scientific warrant; but the recognition of an intelligent force operating, modeling, refitting, renewing, and adapting to ends, is most scientific and reasonable. Reason is everywhere present throughout the unbounded universe. Indeed, were I on a tour through the realms of space, and found a world on which intelligence were not found, where the realm of so-called dead creation were never invaded by the powers of life and thought and love; should I by chance, like Noah's dove, alight for rest on such a world, I should, however weary, instantly renew my flight:

> "Omnibus idem animus, scelerata excedere terra."
> (Vergil: Aeneid III. 60.)

I should feel assured that I had alighted on a monster, a foul creation of some evil-disposed god, an illegitimate child cast out of the house of Nature; or on the corpse of a world whose great heart had once beaten like my own, but now forever had ceased to agitate its mighty frame. For if through its closed eyes no soul shone forth, no pulse could be detected giving signs of the great current of life within; so great is my faith in nature, in its unity and ways, I should feel certain that the globe I had alighted on was but the wreck of a world, a world in ruins; and from such sepulchre I would hasten my flight as from the rendezvous of Death and allied Destruction. Such a world, however, can not be found; for nothing can truly die whose substance is of necessity eternally alive: the form only dies.

It is possibly true that the intelligence of the atom does not enable it fully to recognize its relation to the molecule; nor that of the cell, its relation to the organ; nor that of the organ, its relation to the body; but neither does man fully recognize his relation to the earth, nor probably the earth its relation to the cosmos. Indeed, if physiological health of the organ depended on a recognition on the part of the cell of properly doing its work with a view to such physiological health, without much doubt a pathological condition would soon supervene; just as if the well-being of Earth depended on the recognition by man of his dependent relation to it, and his working with a view to such well-being, disorder and ruin would come to us all. Nevertheless man is intimately related to Earth, whether he recognizes such relationship or not. Indeed, man's relation to the earth is much as that of the fœtus to the mother; and of it to him, as that of the mother to the child. Thus is it also of the interrelation of cell and organ. The former makes the latter; and the latter, once made, always supports the former. Whether such relation be recognized or not, from the fact that every atom and molecule are reasoning beings because of the substance of which they are made, and have worked on such structures for thousands or millions of years, they have become so accustomed to doing their work in their own peculiar way, that they can not do it in any other without violence to their own nature as we see exhibited in malignant tumors, monstrosities, etc.; but if one insists that in general atoms, molecules and organs perform their parts as we take our steps in walking — without any special thought, this would not make them unreasoning beings any more than the doing of many things ourselves without thought makes us such. If a hundred persons were taught year after year for a lifetime to build a house according to certain specified plans, if they never saw, nor heard of any other form, they would finally be able to build as the skilful pianist moves his hands, mechanically. Thus may atoms, molecules, organs and bodies do their work, since they have not learned to do it otherwise; but they are all nevertheless of such stuff as is the Universe itself: thinking, reasoning, conscious Existence.

It is said by some writers on physiology and biology that every cell is derived from a parent cell. This is certainly not true. Every man to-day is derived from man; but his development has not been from nor out of man, but from the very earth itself, and less remotely from the zoön or amœba. Thus with the cell. When there are cells Nature allows them to become the parents of others (She herself does not do any unnecessary work); but where there are no cells, she produces them out of lower beings, atoms and molecules. The ovum is not first, but the atom or molecule taken out of the food which formed the ovum. So of the spermatozoa: they are not first, but the organic and inorganic atoms and molecules which built them up. Nature does not waste energy: she lets her children do their part whether atoms, molecules, or cells, just as soon as they are competent; but she produces the children. The truth is that no cell is truly from a cell remotely: they are always out of simpler elements.

It is amazing how man can not see mind reason and consciousness in atoms and molecules, and yet can be so unreasonable as to see it in man in general. A few days ago a man, ten years a physician, took a note from a man for seventy-five dollars to cure him of a certain disease, and then came to me saying, "Doctor, what is the matter with that old fellow, can you tell me?" Can one who could thus act, be considered a reasoning being? Another physician having been called to treat an infant, came seeking information from me how best to treat the child. Can one who could undertake such work, feeling himself incompetent, be called rational? Do such actions manifest reason? Last Sunday I noticed on Madison street for a half mile west of the river, filthy, squalid, half-naked, besotted, drunken brutes, called men, far lower than any of the higher animals. What evidence do any of these show of the possession of reason? Verily that of the atom or molecule is incomparably more evident.

The Ectocarpus siliculosus, belonging to the algæ, seems very plainly to act in their sexual relations according to feeling, desire, purpose, and volition. So of the spermatozoa, and the ovum in fecundation. The former especially seem very plainly to manifest knowledge of position, desire, preference or choice, purpose, and determination. The spermatozoon sets out on its journey, seeking the ovum, and does not stop until it has found it, and executed its purpose; and the ovum as soon as impregnation has taken place, which, it seems, must be according to its choice, immediately firmly closes up the door through which the successful spermatozoon has entered, thus protecting itself against other male elements, which might in a second or two also succeed in entering the body of the ovum. Reason and consciousness could not be more evident.

In conclusion we affirm that were there no proof of the possession of reason, life, intelligence, and consciousness exhibited by the elements of being, such as atoms, molecules, and cells, we should nevertheless be compelled to infer such possession from the very fact that such elements have been evolved out of the one and only eternal immutable and universal Being, who is of necessity an infinitely wise and conscious substance; else we ourselves, mere derivatives, could be neither intelligent nor conscious; but from the fact that we behold with our own eyes these elementary beings acting according to reason and wisely, we are still more constrained to admit that these wonderful little worlds are truly in possession of life, reason, and consciousness. These qualities or attributes are therefore not acquired in the evolution of organized beings; but they are eternally with and inseparable from the eternal substance of the universe. In a highly developed being life, reason, and consciousness may be more exemplified; but these attributes or qualities are no more belonging to a Newton or an Aristotle than to cells, molecules, and atoms. Though more evident in a god, they are no more belonging to him than to the atom: Substance itself everywhere and always is alive, thinking, and conscious.

CHAPTER XXVII

MIND AND BODY

HYLIC AND PSYCHIC INTERACTION

A COMMON prayer of the ancient Greeks was: "Rain, rain, dear God, on the plowed fields of the Athenians, and on the plains"; and doubt as we should that such prayers ever caused the precipitation of vapor, we have every reason for believing that they enabled the Greeks better to endure the drowth. Cisseis may be believed to have been full of faith when she offered, in her country's dire distress, that most touching, most simple and devout prayer. (Homer: Iliad vi. 290-310.) And although Troy was not spared, nor "the wives and little ones" saved, yet through that invocation blessings were otherwise experienced. Our own welfare, or even that of the least of God's creatures, makes it very necessary that no finite mind should be able to move the deity hither and thither, or to rearrange any of the established order of the infinite will. On the other hand, so far as the preacher, prophet, or priest can persuade the party suffering from a disease to use correctly his own thought or will, he acts rationally, and in many cases will act most effectively. Every one should know that a hopeful state of mind is a valuable possession for a sick man; nor is such a possession beyond the reach of the average mind. Says Marcus Aurelius: "Thou canst pass thy life in an equable flow of happiness, if thou go in the right way, and think and act in the right way." This is a beautiful saying of a very beautiful soul; but like all general statements, it has its limitations. Where there is not sufficient power in the cell or system to reduce a perturbed state to a tranquil one, nor capacity for receiving it, there it matters not how much the sufferer desires to do so, such reduction can not be made.

The well-being of any cell depends on normal innervation; and since the nerves governing such innervation are either directly or indirectly connected with the brain, it follows that the mental state affects for weal or woe the parts or organs innervated. Many instances might be mentioned, such as hysteria, impotence, cardiac palpitation, the blanched or flushed cheek, and the blood-shot eye. In the second of these examples we may have a total loss of energy resulting from fear or apprehension only. But while it is true that a disease may thus have an imaginary origin, it is false to say that the disease itself is imaginary. A run on a bank may have an imaginary cause, but the resulting ruin is not imaginary. Cardiac palpitation may have an imaginary origin in false alarm or groundless apprehension; but the palpitation is not imaginary, nor perhaps its resulting hypertrophy and dilatation. A person thus suffering, or suffering from impotence, is not likely to be benefitted by being told that his troubles are imaginary; but were he informed that although his troubles are real, they result from groundless fears, there is a probability that with proper treatment permanent benefit might be experienced.

It is probably true that fitting ability thus to advise is possessed by him only who has a good physiological and psychological education. It is doubtful if physicians as a class recognize or sufficiently appreciate the work of the mind in therapeutics; and it is this failure of the medical profession to make use of psychological therapeutics that has been the chief cause of bringing into existence the many forms of faith-cure with all their exaggerations and contradictions.

The work of the mind in therapeutics is not uncertain nor miraculous; but although it may be fairly understood by any person of average intelligence, the doctor of medicine should make it his first duty to comprehend it fully.

Aristotle tells us that God can not be known except through his works; so mind can not be known except through the works of the mind, and these can not be understood except through a knowledge of the nervous system. So intimately connected are the workings of the mind with the nervous system, that the normal action of the former depends on the normal condition of the latter.

The nervous system is one; but for the purpose of greater clearness its exposition is generally divided into two parts — that of the cerebro-spinal, and that of the sympathetic, system. The sympathetic nerve extending on each side of the vertebral column from the base of the skull to the coccyx, consists on each side of three large ganglia connected by a cord, of some smaller ganglia governing the abdominal viscera, and of numerous nerve fibres. These two nerve chains come together in the skull and at the coccyx. In addition to these connected ganglia those belonging to the third cranial nerve are held by many to be a part of the sympathetic system. The sympathetic system is composed mainly of non-medullated fibres; but with these are mixed some medullated ones, which come from the cerebro-spinal system through the branches of the latter which communicate with the different spinal ganglia. Every cell in these so-called two systems are directly or indirectly connected with every other cell, of whatever kind, in the human body.

The central nervous system is composed of the brain, spinal cord, and peripheral nerves. In the brain the grey matter is external; in the cord, internal. Both brain and cord are protected from injury by three coverings called the meninges. Really the cord is but the continuation of the brain; but for discrimination it is made to begin at the conus medullaris and end at the coccyx. Giving bones for landmarks the cord begins at the upper part of the atlas, and ends at the lower part of the first lumbar vertebra. It is from seventeen to eighteen inches long in the adult, and weighs about one-and-half ounces.

Arranged alongside this cord are thirty-one pairs of nerves each of which is said to have two origins, a deep and a superficial; the deep being from the grey matter of the cord, the superficial being from the anterior-lateral and the posterior-lateral grooves. The unit of the nervous system is called a neurone, and is made up of its cell, axis-cylinder, and prolongations. Like insulated wires in a core these neurones lie one upon another: and although they are not believed to anastomose with one another, they are nevertheless connected by their processes, collaterals, and plexuses. The nerves arising from the anterior-lateral part of the spinal cord are motor, those arising from the posterior-lateral are sensory. Fibres from the motor nerves can be traced to the brain, where connection is made with sensory nerves, thus bringing into direct relation the center of volition and voluntary movement with the nerves of sensation and feeling. Thus are the internal and external worlds brought into direct relation with each other.

The axis-cylinders of the posterior or sensory nerves soon divide, on leaving their cells in the spinal ganglia, into two parts, one going to the spinal column, the other to the periphery. The cells for the cranial sensory nerves are in the sensory ganglia; those for the spinal sensory nerves are in the ganglia just outside the cerebro-spinal axis. The cells of the spinal ganglia, as has been stated, have a peripheral and a central process. The peripheral is dendritic, and connects the body and the organs of sense with the cells of the spinal ganglia; the central is axis-cylinder, and connects the cells of the ganglia with the cord, where there are central neurones to connect the peripheral ones with the higher nerve centres. These central neurones pass to the brain, where, as has been said, connection is made through the brain with motor nerves.

In tracing a sensory impulse we may say that sensation passes from without first to the ganglia cells, where motor impulses may be evoked reflexly from the cells in the anterior horn of the spinal cord; or such sensation may pass by various routes in the cord to the brain. In the former case we have unvolitional or unconscious motor action sent out in answer to the waves of sensation received; in the latter case, volitional or conscious.

In tracing a motor impulse from the brain we may say that it starts from the peripheral cells in the convolutions which lie around the fissure of Rolando, and descends via the anterior two-thirds of the internal capsule, the anterior portion of the middle third of the crus cerebri, and the medulla. Arriving here most motor impulses, as at this place most motor fibres, cross over to the other side; but those that cross and those that do not, all alike end in the cells of the anterior horn, where motor impulses stop seemingly for a fresh supply of energy to complete their work on nerves and muscles. Sensory impulses can not be so clearly and definitely traced as motor; but they proceed inward from the periphery or elsewhere to the centre, although on arriving at the cells in the spinal ganglia they likewise stop to renew their energy in order better to complete their work on the cells which originate action in answer to the demand of the sensory impulse. These impulses are therefore like long-distance runners who stop over for a time at some half-way house to recuperate.

We are not saying that mind is some entity which acts in and upon the body. We are speaking rather of the phenomena of mind, and how it is manifested. We have already stated that mind does not exist apart from matter nor matter apart from mind. Matter and mind are truly only phenomena of Substance. Sir William Hamilton says: "When God is said to create, we construe this as meaning that he evolves existence out of himself." This is strictly correct. Bain, Tyndall, and Huxley each and all hold to one common and universal substance; and Richter says: "The various elements must be condensations or aggregations of the one and same primordial substance." It is not to be doubted that the world of science to-day is in full accord with the position of these justly celebrated scholars.

We have elsewhere given the reason why this one common substance can not be considered matter; and for similar reason we have shown why it can not be considered spirit. Our work in this chapter is not to repeat what has been said, but simply to give from a scientific standpoint the correlation or interdependence of mind and body, with special reference to man.

Perfect health is perhaps never enjoyed. Therefore health and disease are relative terms. In general a person may be said to be in normal or good health, when able to attend to life's duties without feeling any unusual discomfort; but when disease comes, it must affect one or another of the following — the circulatory system, the absorptive system, the excretory system, the secretory system, the digestive system, the reproductive system, the nervous system, the muscular system, the osseous system. Each one of these systems is reached directly or indirectly by the mind; and great as the work of the mind is in curing diseases founded on pathological states of some of these systems, it is much greater in curing diseases founded in imaginary evils. Says Euripides:"*Κἂν μὴ νοσῇς γὰρ, ἀλλὰ δοξάζῃς νοσεῖν, ἀπορία*—Even if thou art not really sick, but imaginest thyself to be, the difficulty is very great." (Orestes 314.) Similar assertions can be found in all ancient literature. Imagination is very powerful. In hysteria the person attacked, when able to hear and answer questions, always experiences the state he is commandingly told he is in. Thus also with hypnotized persons; and without much doubt many more have died through fear, having been bitten by a dog than really and truly from the dog-bite itself. Mental emotion or excitement may produce many troubles, among which may be mentioned — insomnia, stammering, hysteria, traumatic neuroses, functional paralysis, dystochia, impotence, heart disease, and even recrudescence of typhoid. The force of the will is well known of old. Says Plautus: "Quamvis malam rem quaeras, illic reperias." (Trinummus 554.) "Man," say the Upanishads, "is a creature of the will. If thou art sick, say ye Pranas, ye Adityas, extend my life. Then shalt thou become whole." Says Epictetus, "It is the will which makes happiness and unhappiness." And in speaking of opinion he says, "We should remember that nothing else is the cause of perturbation. Man's opinion about each thing is that which hurts and overturns him." Says Antoninus: "Take away thy opinion, and then there is taken away the complaint. How easy it is to repel every impression which is troublesome and unsuitable, and immediately to be at tranquility." Says the Upanishads: "Mind alone is the cause of liberty and bondage. He who sees this, does not see death, nor disease."

There is truth in each of these references, but there is also error: they are exaggerations. We must take care not to go to extremes; for thinking a thing is so when it is not, will not make it so. (Euripides: Bacchae 310.) Rheumatism is rheumatism whatever our opinion may be; influenza does not become a simple rhinitis by affirmation nor denial. A sarcoma is not changed into a benign tumor by asking, willing, or denying. The fœtus is not removed by willing it elsewhere. What is, is, whether we will it or not; although in time what now is, may not be. We should not deny headache where headache is, nor matter where matter is, nor pain where pain is. Our work while admitting all these, is to seek how best to remove the evils connected with them. Mind is not something added to matter, nor is matter something essentially distinct from mind. Mind is coextensive with the bodily substance, and is in every molecule and cell; although the brain is the special seat of its manifestation, because it is the place where so-called will-power is focalized. It is, as it were, the "central" of animal life, to which and from which movements are continually speeding; and this is no more difficult to understand than that some great center for buying and selling stocks and bonds should be more alive with electric and telephone wires than is the outlying territory, although the force passing along the lonely country road, and confined to a single wire, and creating no bustle at all, is of exactly the same nature as that at the stock-broker's desk. Fibres from the motor nerves can be traced to the anterior pair of the corpora quadrigemena, where they give off collaterals to the motor cranial nerves which connect the peripheral sensory cranial nerves with the cells of origin of the motor cranial nerves, the cerebellum with the nuclei of origin of the cranial nerves, and the cranial nuclei with one another.

The motor and the sensory areas of the cortex cerebri have been carefully mapped out after much experimentation. The motor areas are in the paracentral lobule, the ascending frontal and the ascending parietal convolutions. The sense areas are (1) for common sensibilty in the same regions as for the motor faculties; (2) for the sense of sight, in the cuneate lobe and the angular gyrus; (3) for the sense of smell and taste, in the top of the temporal lobe; (4) for the sense of hearing, in the upper temporal convolution. The chief intellectual centres, called by some the associate areas, occupy two-thirds of the cerebral cortex—most of the temporal, parietal, frontal, and occipital lobes. These intellectual centres can not be stimulated from outside.

Every atom whether in that of the human body or in that of a bacillus, is a thinking atom; but atoms located in some parts are, as it were, more nascent, therefore more active than those in others. The work of different atoms is different. The work of the reproductive cell is to preserve the form and characteristics of the living being from whom it comes. Hence the facts of heredity are natural and explicable. Even the nucleus of the cell whose work is to reproduce its kind, must have potentially all the peculiarities of the individual in whose organism it was formed. The Gentile never produces a Jew. Hence we have hereditary such as hysteria, mania, insanity, melancholia, alcoholism, progressive paralysis, depravity, erotopathy, neuroses, hare-lip, right-sided heart, unusual number of digits, fibromatous nerves, peculiar retinal pigmentation, gout, deaf-mutism, and various other anomalies. Such congenital characteristics sometimes pass over one or more generations to reappear in the next. Even a tendency to a disease may be transmitted, such as that to tuberculosis, cancer, or insanity. Many of these facts have been long well known. Aristotle (Historia Animalium vii. 6) speaks very clearly on the subject, enumerating a great many peculiarities as transmissible.

Mind therefore acts on matter, or the so-called mental part affects the so-called material part, through habit, or through a certain intellectual resolution, determination, or purpose to have one's condition conform to his desires. Whenever such habit is possessed, or such resolution, determination, or purpose clearly expressed, as in business-life it affects one's personal condition, so in our elementary life it affects every cell either directly or indirectly. Some have held that even the sex can be determined by the will, but this is not to be believed: nature would never put herself thus within a creature's determinative power to be subject to mere caprice.

One of the first things a physician should do is to inform the sufferer how much of his life is in his own hands.

If one can be made cheerful, hopeful, determined to get well, half of the physician's work is done.

We must not forget that neither mind nor soul has ever been found as an entity. Mind is an abstract term used to denote all the phenomena of psychic activity exhibited especially by animals and most of all by men. The phenomena of mind consist fundamentally in the manifestation of choice; and more specifically of volition, memory, and consciousness.

The seat of all such phenomena is in the cortex of the brain. It is through the afferent and efferent nerves that man is affected by and affects the outer world. It seems that the seat of psychic force should rightly be considered the whole nervous system. This system is not at all unlike a telephone system of a city, or a telegraph system of a country. A nervous impulse moves at the rate of about 33 feet a second.

The nervous system is indeed a wonderful piece of mechanism which the living substance has generated beginning even in the amœba, and seemingly on this earth ending in man, for the purpose of keeping all the various parts of the body in touch with one another, every thinking cell *en rapport* with all the others.

Many a sufferer dies through the lack of sensible guidance; for few are they who recognize as they ought the work of the mind in illness, and least of all how to set it in action. How many perish of heart disease who might have weathered the storm, had they been able in time to cast off the burden of anxiety, the constant dread, the terrible oppressive feeling which haunted them go wherever they might. He who would save such sufferers, should first set about treating the mind. Religion and philosophy have an influence in such cases unequalled by any other therapeutic aid. Especially is this true of religion. To the believer prayer, faith, confidence bring peace and rest; to the philosopher like Epictetus and thousands similar, the consciousness that God has done and is doing all things well, brings equal tranquility of mind. The tumultuous heart, if thus timely treated, hears a voice, "Peace, be still." In every other disease there is similar, if not so evident, help from this correct mental state; for as has been said, there is no cell beyond the reach of the mind. Confidence, determination to get well, is of unspeakable help to the sufferer, it matters not of what disease; and when we know that not a few, perhaps the majority of human ills, terribly real as they are, have their origin in only imagined evils, one can not fail to recognize the still greater necessity of treating the mind in disease. And all such work is based on natural law. There is no miracle. For although there is a truth underlying the claims of all forms of mental healing, the source of mental healing is not from without but from within. If hypnotism heals, it is only because the mind of the patient thus subdued sets about doing what it should have done as a free-will agent. Whatever part the mind has in healing the body, is accomplished by no other mind than that of the sufferer. It is ever true: "Thy faith hath made thee whole," and not another's. Let the sick, therefore, be hopeful, cheerful, prayerful, confident, determined, and not a little of the victory is won. Every cell in the body feels the influence of such mental repose; and feeling it, goes about doing its part, and inciting other cells to do theirs. Digestion, secretion, excretion, metabolism, the circulation—all are moved to take up the work by nature assigned them.

We must not, however, forget that all movements are limited. If a body moves by nature in only an elliptical orbit, it can never safely move in an orbit whose centre is equally distant from every part of its course. So the movements of the procreative cell are free within certain limits; but beyond these it can not go. Sometimes these limits seem almost transgressed, and monstrosities appear; but the horse begets only the horse-kind, and the pig the swine-kind. For this reason also genius is not generally transmissible: only what is truly human, or in common by humanity experienced, can generally be transmitted. Thus there are limitations to movements of nucleus and cell, and to the manner in which the cells may combine and arrange themselves. A mathematical equation may often be represented by a curve having maxima and minima values. Such equation may be satisfied with any value for the unknown quantity within certain limits, and all such values will be on the curve representing the equation. So while man's vital forces are able to move along the curve of life, the mind may lend its aid; but when life's rhythm is broken, and the curve departed from, the organism must dissolve, notwithstanding any mental effort to preserve it. Weak is the mind in a failing body. The time for mental action is while yet the body is not beyond recovery, and the mind has determining force. Procrastination is dangerous here as elsewhere. "To-morrow" is too late. The mind has no power to save from dissolution what by the very laws of its being has passed the limits of possible recovery. But before the breaking of the curve on which our life-forces move, before the forces of life are overcome by the forces of death, much may be done by the mind to preserve the body, and to keep it from going to those extremes where chaos and destruction await it; and much may be done by medicine to assist both mind and body to regain the health that is lost. There is a time therefore when nothing can save from death; but while salvation is possible, it should be our aim to arouse the patient, and direct him how to do his part in combatting the disease. We should without delay treat the mind of the patient; and we should be careful to do this before it is too late. The atoms in health move in harmonious orbits, and the cells and their multiples in rhythmic and harmonious activity; but in disease they lose some of this rhythm and harmony, while in death all fall into confusion.

Intelligence is an attribute not only of mind but also of matter, whether it be the atom of carbon or the molecule in the venom of the rattlesnake. By this we mean what has been said before that intelligence is an attribute of each of the two expressions of substance—so-called matter and so-called mind. When a person acts truly intelligently he does not deny sickness, when the organism is deranged; but while admitting it, he intelligently seeks to correct the pathological state. A heart laboring to drive the blood through the kidneys and to the extremities, is certainly benefitted by mental treatment; but so may it reasonably be helped at the same time by the material side of substance.

The frightful agony of angina pectoris must be seen to be conceived. The patient stricken with this dreadful disease has the horrors of death stamped on his features. To treat him mentally is of vast benefit; but give the poor sufferer some one of the thrice-blessed drugs known to-day to relieve the laboring heart almost immediately, and you soon may be able to leave the sick chamber feeling you have not come in vain. A man has a bad case of acute rhinitis. Sneezing, coryza, lacrimation, headache, and rhinal turgescence make him unfit for duty or society, and a disgust to himself. Prayer and faith will do him no harm; it may do him some good. But as a sensible person cleanse the nasal passages, see to the state of the bowels, ease the headache, stop the sneezing coryza and lacrimation, and advise the sufferer to remain, if possible, in an equable temperature. Do all this in two hours. With the afflicted life is worth living again; and you yourself realize the value of having a cerebrum.

But while the world endures we need not hope to see man freed from superstition. His exalted opinion of himself as that of all God's creatures on earth he alone has been chosen to be the object of his special love and providence —this conceit makes him a ready victim of any teaching that may be calculated still to strengthen it. One superstition passes, another comes. Man is unwilling to believe that the despised sparrow is as much the object of God's care as is himself. Fortunate is he who really understands this; for such a person may be led to keep his "own house in order." Conscious that natural law governs him as much as it governs the unfolding chrysalis, he will dread its violation, knowing its consequent penalty.

Only a few years ago twelve months or less of study gave a physician a license to practice; and in some states licenses were granted without any special requirements. Even where a certain course of study was exacted, there were only most elementary requirements preliminary to the study of medicine. Boston University was among the first, if not the very first, to recognize the necessity of broadening the course, demanding in 1877 three years study as a condition of receiving the medical diploma, and in 1890 four years. When one knows that mental power is proportional to the length, breadth and depth of study, and that correct diagnosis, being based on sound judgment, depends on such mental power, what can one expect from therapeutics? A president of an eastern college a short time ago announced that hereafter no one would be accepted as a student in the medical department who had not taken a college degree. This is encouraging. When all colleges take a like stand, patients may have hope; and when all states demand it, the people should sing a "Te Deum laudamus." Most state-boards to-day exact a high-school education preliminary to medical study; but their laws have too many "ors" representing acceptable equivalents. Mercenary deans are great contrivers of plans for nullifying the laudable requirements of state-boards.

We know that medicine offers no great rewards for long study preparatory to such professional learning; but when the life of our fellow men is at stake, it is necessary that the doctor should not greatly err. Where he can do no good, it is most to be desired that he do no evil. We may read in the cemetery "requiescat in pace"; but the dear departed ones, and their name is legion, might arise, if only they were able, and cry: "Medicus nos hic imperitia ingessit." The doctor of medicine needs a mind well developed, well balanced,—a mind embued with a love for man, and filled with the fear of doing something that may offend the holy one within him, no less than he needs a mind rich in scientific attainments. The New York Homeopathic College has just announced an optional course of five years. This is a move in the right direction, and adds honor to homeopathy. Many students will avail themselves of the privileges offered in taking such a course. A full course of collegiate study should everywhere be required as a necessary preliminary to the study of medicine. Drugs are too dangerous, and life too precious, to be intrusted to incompetent men; and however well endowed one may naturally be, he must remain, if he has not high intellectual qualifications, unfit to have the precious lives of our dear ones in his power.

When our medical schools turn out men morally and intellectually worthy of the sacred trust the patient is obliged to place in the keeping of his physician, the foolishness of long-distance treatment, and of much passing under the name of "mental science," will disappear; and man will know that nature has no more failed to produce remedies for pathological conditions than means for satisfying natural wants. In the treatment of the sick, mind will not then be enthroned to the debasement of matter. Substance pregnant with energy divine in origin and character will be increasingly at the command of the physician; and knowing the interaction of mind and matter, their mutual dependence, and the special work of each, he will not fail to use each aright. Whether such men shall go into the hovels of the poor, or into the mansions of the rich, hope and comfort will go with them; and to many a despairing heart they will say, "He is not dead but sleepeth"; and to many seemingly sick unto death, "Take up thy bed and walk." Such is the interdependence of body and mind, and such the interaction of mind and matter.

CHAPTER XXVIII

THE SOUL OF MAN

OFTEN as the word, soul, is on the lips of men, it can not be said that the conception is always of some part or element of man that can not die; for many use this word to denote some quality or attribute; others use it as a collective term denoting the unification of all the higher phenomena, the moral and spiritual qualities. Nor can it be said that man has an innate knowledge of anything in him that must survive the dissolution of the body; for multitudes have never heard of such, nor have even a word in their language to denote it.

The meaning we give the word in the present chapter can not be misunderstood.

As one approaches the time when he naturally expects to go the way his fathers have gone, he becomes less inclined to fan the flames of strife, and less given to condemn those who differ with him.

In the consideration of the subject of the present chapter, it is not at all probable that some of my readers will not disagree with the views expressed; for had such teachings been given me thirty-five years ago, I myself should have refused to accept them; and at that time I considered myself competent to pass judgment on the scientific and philosophic accuracy of such writings. But writing with a calm spirit, and fully conscious of what I was in those days, I know that I was not then competent to pronounce such judgment. I therefore ask my readers to consider carefully what I shall have written, lest in judging hastily or captiously they may do themselves injury in failing to receive the benefit of the truth: it is the truth only, whether we like it or not, which can eventually result in good.

Without much doubt the great majority of uneducated people believe that man possesses a dual nature—that he is in one aspect of his nature essentially material, and in the other essentially spiritual. There have been those who have held, and there are those who hold, that man has a material and an animated nature such as have all animals, and a spiritual nature such as no other animal possesses, and which is believed by them to unite man to God, and to make him, what they say he is, a being of deathless existence.

All biologists, all physiologists, all psychologists agree that there is nothing in Man which other animals, especially those of the higher orders, do not also possess in kind. We admit that such intelligence and affection as we often see exhibited by higher animals, is not a characteristic of so-called matter; and if the manifestation of such attributes by Man forces us to consider him as a being linked within the veil to the immortal gods, we are for like reason compelled to admit a similar future for at least the higher orders of animal life. It is true that not a few believe in such a future for animal life in general; nor is there anything known in science which makes such belief either absurd or irrational. The writer, however, feels compelled to state that in his judgment, if the realization by man of immortal life depends on the truth of the supposition of the immortal nature of animals in general, we have but little reason for a hope of life after death. And further the writer must state that if one founds his hope of immortality in any inferred essential difference between matter and mind, he has no scientific nor philosophical warrant for such hope; for we have repeatedly stated that the universal essence is of necessity one and only one, and that matter so-called and mind so-called are but attributes of the same and only eternal and universal existence. The thought of two infinite, eternal, and universal substances is self-contradictory, and unthinkable. No theist doubts that God is true being, nor does any materialist doubt that behind all phenomena there is eternal and indestructible substance; and the philosopher knowing that the thought of two eternal, indestructible, and universal essences or substances is self-contradictory and unthinkable, affirms that the being which the materialist postulates as necessarily existing behind all phenomena, and the being which the theist and the spiritist postulate as the eternally and universally existing Creator and supporter of the universe, are one and the same Eternal and Universal Existence. The materialist viewing existence seemingly with half-closed eyes, and preconceived notions, affirms that all existence is material; the spiritist equally dull-sighted and obtuse affirms that all existence is spirit. The Christian theist and most other theists teach that there are in the universe two essentially different existences, the one being material the other being spiritual; and although all such theists teach that God created matter, they fail to see that therefore creation and Creator must be one in kind and nature. But the philosopher knows that if God created matter so-called, he must have created it of necessity out of himself, since he himself admittedly is universal and eternal existence; and that therefore Creator and creation are one in substance and nature. In agreement with such philosophy the writer asserts that there is nothing in man which is not found in kind in all animals, and more remotely in all substance; but although this is scientifically certain enough, the writer does not believe that therefore Man has no higher claim to immortal life than other animals. Philosophically we must be monists; but it does not follow that we must be materialists or spiritists. As the substance of a meteor a few ounces or a few pounds in weight does not have the same power to overcome destruction through friction with the atmosphere as one several hundreds in weight, although each be of the same substance; so the animal world in general, and even the higher orders, possessing throughout the same essence in their being as Man possesses, may nevertheless not have the same power as Man to overcome the destruction of their identity through the dissolution of death. Not only from the fact of Man's incomparably superior self-consciousness to that of the animal-world in general do I believe that he has some reason for the hope of immortal life; but the writer is given to believe that many men, if not Man in general, may have received in the past, and receive in the present, an influx, as it were, from the Deity, through their knowledge of, and their faith and trust in him, which influx may make them superior to death. Nor do I mean that such influx would or could be immediately from the substance of the Deity; but it might be incomparably nearer to the divine existence in simplicity than any substance we know, — as much nearer, for instance, than ether as ether is than the common atoms. We know that ether can not be recognized by us. We may exhaust the air in a receiver through various means, until it is near to an absolute vacuum; but not only have we no mechanical means for reducing the volume of ether in the receiver, but even no scientific knowledge how it might possibly be done. The pressure of the ether is very great. By calculation its density is inferred to be 936/1000,000000,000000,000000 that of water (Clerk Maxwell), which is about equal to that of our atmosphere at a height of 210 miles, and its rigidity to be about 1/1000,000000 that of steel. It easily penetrates all bodies, and is believed to be unaffected by gravitation on account of its extreme tenuity, and to be continuous, not granular, as if a universal homogeneous jelly. The most perfect vacuum conceivable is full of ether. Herschel held that the pressure of the ether per square inch is about seventeen billions of pounds; and Langley says that we are scientifically acquainted with ether-waves having vibrations between the limits of about

107,000000,000000 and about 40,000,000000,000000 per second. All bodies, therefore our own, have an ethereal body within, and delimited by, their physical bodies. This is true of all bodies scientifically known to us, whether organic or inorganic. The writer believes that ether is as far removed from absolute existence, or the original essence of being, as it is from hydrogen, and perhaps incomparably farther. Therefore somewhere in the line of evolution of substances out of Absolute Being up to ether there is a point where the substance is so simple as that none of the common forces of nature can resolve it, and no human sense discern it; so simple that it passes readily through every physical body known to us. This is what I call the soul-substance. It is incomparably near to the infinite and absolute Existence, God, true life, and eternal being; and as every scientifically known body has within it, as has been stated, an ethereal body, every animal must therefore have an ethereal body coextensive with, and delimited by, its own material form. And as the substance from which I have stated the soul is derived is incomparably more simple than ether, there are therefore within every material form and delimited by it, two other forms neither of which can be discerned by us, the one being ethereal so simple that it readily passes through every known physical substance, the other being soul so simple in its nature that it readily passes through even the delimited body of ether. This soul-substance is therefore truly possessed by every physical body, whether an atom of carbon, a morning-glory, or bird, or beast, or man. But every soul may not be derived from points, in the evolution of existences, alike near to the Absolute Existence, God. The stability, indissolubility, and indestructibility of the soul depend on the nearness to absolute being of its point of derivation; and also on the intensity, depth, and quality of its self-consciousness.

The soul's immortality is probably also conditioned on its converse with God. Even if a soul were derived immediately from the Absolute Essence, yet perhaps it would not be immortal, unless it became godlike in the possession of high and lofty thought, and a consciousness of being rooted in the Universal Life, and of communion with God. In such a state the soul is truly awake, on its guard as it were; while the soul in the body of one of low and debasing thought, conscious of being rooted in, and driven by, the pleasures of the world, without communion with God, is truly asleep, and not on guard. The former in death holds naturally on to its personality; while the latter, unfitted in every way for individual existence, may sink into the eternal and Absolute Existence, and forever lose its personality.

It is not impossible that we may find in this threefold body of man an explanation of apparitions, especially of those said to occur immediately after death; and of the many ghost-stories, and apparitions in some cases even of animals. My own mother, at the time living on the island of Jersey, in a large old mansion surrounded with a high court-wall, and sitting in the recess of a large window, engaged on some embroidery work for the expected child, plainly saw, as she thought, her father pass the window at midday. She rushed outside to welcome him, and was amazed to find no one there. The gates of the court-yard were still fastened, and no person could be found within the enclosure. She was greatly affected; but in a few days she thought the vision was explained: she then received a letter saying that her father had died in Flushing, south-western England, at that time, speaking of her with his latest breath. What did my mother see? Was it merely a phantasm of the brain? Perhaps so; but I think it may have been the second or ethereal body of which I have spoken, as being one of the three bodies of man. This would seem to be what many call the astral body, and is much more bound to earth, because more closely allied to it, than is the soul-body. I conceive it quite possible that under peculiar conditions at death, such as intense desire to speak of certain matters or to a person, this ethereal body, slightly stamped with stable identity or abiding personality, might retain its form for some time, perhaps in certain cases until the desire is accomplished.

One may reply that it is impossible to see an ethereal body. I answer that such a body although arising out of the pure ether, may through long or even short association with the earthly body, be more or less, as it were, contaminated, and because of this might preserve the form of the body after death for a short time, and with obscure form, especially when it has been deeply impressed with the desire or longing of the soul or even of the lowest body. Such indefinite personalities, it seems to the writer, may be the explanation of much of the disconnected and often meaningless jargon we hear at many spiritualistic seances. Certainly there are intelligent forces at work there seemingly at times trying to reveal themselves; but they generally are intelligences of a very low order, uncertain of themselves, and indefinite in all their conceptions as well of this world as of the world to come. Such may be the unstable, wavering, indefinite, ethereal body for some time before losing itself forever in the Universal Personality.

I do not affirm that the true spirit or soul of man has ever been seen, nor do I affirm so much even of the ethereal or astral body; but I must admit that we have very much affirmative testimony for the appearance of apparitions and ghosts, whatever that may mean. Most of such appearances, if not all, may be explained, in the writer's judgment, by supposing that in each case it is the ethereal body which is seen.

At the Common Law to make a crime homicide it was necessary that the person killed should be a reasonable being. Therefore it has not been considered murder to kill a child in the mother's womb. Even in the church it was a mooted question, and is one far from settled to-day just at what time, if at all before birth, the foetus becomes a living soul. If for each body a soul must be created, the question is, when does God create it. Is it created during foetal life? If so, at what stage? Is it not created until the child has become an independent being? If so, at what stage of its independent life? All this difficulty is overcome on the supposition of a threefold body; for every atom has such a body, every molecule, every cell, every organ, therefore the ovum, the sperm, the foetal germ, therefore the fœtus, therefore the child at all stages of existence. The character of the soul, however, is modified through its relation to the other bodies, and expands with them: and its personality intensifies, and becomes increasingly permanent, as its self-consciousness grows through intercourse with the world below and the world above, or through a knowledge of the material world, and a knowledge of God: for the probability of its attaining immortality is directly proportional to the intensity and depth of this self-consciousness.

One may object to the soul-substance being derived naturally from universal soul-substance, as the ether in a body is derived from universal ether, on the ground that it is difficult to believe that the same soul-substance can remain in the body, because such a substance would more probably be always changing for other similar substance as the body changed its position in space; but such were not a valid objection. The perfect elasticity of the ether, its great tenuity and homogeneity lead us to infer that any volume of it is readily displaced by another equal volume without any appreciable expenditure of energy. In other words, the ether is perfectly translatable. The same ether that is now in a body may therefore permanently remain in it, however much such body changes its position in space. Much more readily is the soul-substance translatable; and much more certainly does it permanently remain in the body it first penetrates, until such body is dissolved in death. The soul therefore does not depart from the body during life; it is necessarily with it as is the ethereal body. Because of this close association of the soul with the body, the writer conceives that it must thereby receive the form of the body, and that it holds such form until the end of its identity, if end there be. How long such form can be retained after the dissolution of the body depends, in the writer's judgment, very much on the character of the soul, which as has been stated, depends on the kind of life lived, and the intensity and quality of consciousness,—in other words, on the degree of personality. *I* fail to see what scientific reason can be adduced for believing that Man is naturally immortal. Certainly the highest animals live a much more natural and reasonable life than the lowest men. I also fail to see how one can on scientific grounds believe that animals in general, or even the higher orders of the mammalians, will retain their identity after death; but it does appear reasonable to believe, as has been stated, that immortality is a natural gift to the soul that has attained a high and noble personality — in other words, great intensity, depth, and highest quality of self-consciousness.

It may be reasonably affirmed that we find some evidence in Spiritualism for the existence after death of the soul of man. I have witnessed many phenomena which give support to such affirmation. The writer is naturally a skeptic, always exacting the most unquestionable proof before accepting anything as true. It is this mental property that forced me out of an excellent church communion. Such a mind is not conducive to ease, but quite necessary to the lifting up of the world.

In 1897 I was invited to pass the noon hour at the residence of a noted medium in Quincy, Illinois. After a few minutes loud and rapid knocks were heard on the table at which we were sitting, and the medium asked me to question the spirit. My reply was that I neither regarded it as a spirit, nor knew what to say. She then asked me to inquire if any of my friends were at the table. To this question I immediately received three loud raps. In a few moments the message came that the person at the table was she that was once with me in New York in 1876. I then inquired if she could write her name on the slate. (I had myself cleaned the two sides of the slate, put a small piece of pencil between them, bound them together, and placed it beneath the table, which was covered with a dark-red cloth reaching near to the carpet.) In a minute I distinctly heard a scratching sound, although I was in every possible way guarding the medium, and am sure that neither a foot nor a hand of her was near the slate. At last a peculiar sound was made; and the medium informed me that it meant whatever could be done, was already done. On looking at the slate I found fairly plainly written, "Aggie Lewarne." Certainly the medium had never seen her, nor do I imagine that the thought of the name was at all in my mind so as to enable the medium possibly to read it telepathically. The medium then asked me to put my hand beneath the table, through a hole in the tablecloth, saying that possibly I might be able to feel the hand of my friend. I confess that the thought of such a handshaking affected me every way but pleasantly, and I did not do as she suggested; but I immediately felt the pressure of a hand, inside the cloth, against my leg. I made a careful examination: there was the cloth coming against my leg and the pressure, seemingly, of a hand, although the medium's feet were not near, and her hands were upon the table. I concluded that the phenomena of Spiritualism were well worthy the severest examination.

About two weeks after the above occurrence I was with my children seated at a table, when an alleged spirit came giving his name as Kapusgnoti Groprrl, and expressed a desire to be my "control." I replied that with my consent no spirit, whether dead or alive, should be my control;

that my reason was my own, and that I would not be responsible for another's. After some time he admitted that he could not control me, and that he was desirous of being my guide and friend. Of himself he gave us to understand that he had been murdered in Arabia 4500 years ago by emissaries from the king of Egypt, who had become jealous of his power as a priest; that his body had been embalmed; that he is now engaged in educational work on the planet Jupiter; that he knew my departed wife, but not my father. He then brought to the table the alleged spirit of my wife, who talked much as in the days of old, and most feelingly of her children then present at the table, repeating to me the very words she had said of her oldest child on first beholding it; she also encouraged me with many words and sweet remembrances. At another time Kapusgnoti Groprrl came manifesting great sorrow. On inquiry he told us that his sadness was caused through ingratitude on the part of many of his students who desired to have another president. From his standpoint he thought his experience of 4500 years, his faithfulness, and the grand results of his work merited better treatment. On my asking why he had come to us with his trouble, he replied that he wanted us to help him. At this we laughed, and asked why we could render any assistance. He answered, by voting for him. I then drew up a resolution, setting forth our reasons for wishing Kapusgnoti Groprrl to retain his position as president; and we all signed our names to the resolution. On asking if that was what he wanted, he replied, "yes."

"When shall we know the result?" I asked. "In fifteen minutes," he answered. Everything thereafter was perfectly still; but at the end of fifteen minutes the table jumped, as if in great joy, and the answer came, "I am elected! I am elected!"

"And do you mean to give us to understand that our votes had anything to do with the results?" I asked. "Most certainly," he replied. "Your resolution affected hundreds."

On further inquiry who was the party put up in opposition to him, he answered that it was Lord Tennyson.

At another time I asked Kapusgnoti Groprrl, what is the divine Being; and he replied, "ἥ δλη φύσις — The whole of Nature."

At another time in the city of Muncie, Indiana, I was by request one of a few friends who were sitting in a circle. The medium was at my side. First a little child of about five years seemed to manifest itself, saying it had come from Washington. It had been talking to several audibly, when it came to me. I asked how long it was in coming from Washington. She replied, "just a thought." I answered that her reply was not what I wished, that I wanted her to tell me how long a time she was in coming. The husband of the medium thereupon protested that the answer was sufficiently definite, and that I was trying to break up the meeting.

Then the alleged spirit of a priest came to me, wishing, he said, to converse. I replied that I was very desirous of receiving any proof of the existence of the soul after death; and said, "Magister sacerdos, quam multos annos mortuus es — How long have you been dead?"

The ignorant husband of the medium again protesting at my use of a foreign language, I left the meeting; and I was afterwards told that it had better success after I had left.

At another time I spent an evening at the residence of a physician in the same town. After a while the table began to move. On inquiry who was present, the answer came, "I do not wish to tell you." After much entreaty, however, in reply to the question of what disease the party had died, the answer came, "Of no disease. I died under the knife." "My God!" the physician exclaimed, "that was my sister. She died while being operated upon."

I believe that it is philosophically certain that if there are spirits they must be subject to infirmities; they must be imperfect in knowledge and wisdom, and always capable of improvement; that among them there must be, in all probability, some who could not if they would, and others who would not if they could, give us sensible answers to our burning questions. But given the existence of spirits, it is reasonable to believe that some would be present with us, and endeavor to manifest themselves to such as long for their communion, and are sensitive to their approach; and in a harmonious circle where every one is laboring for such manifestation, it appears quite reasonable that it might occur. In the month of September, 1885, I was in my room, in Manitowoc, Wisconsin, being at that time rector of St. James Church, when I heard a voice plainly saying, "R. B. Hare is dead." It was only three or four days thereafter when I received a letter speaking of the sudden death of my friend, R. B. Hare, at Guelph, Ontario, Canada.

I have been acquainted with many prominent mediums, and with very many Spiritualists. Among the former I am convinced I have found some of great sincerity and truthfulness; and among the latter there are those not second to any in beauty of mind or sincerity of heart. There are, however, many false men to be found among all classes. I have known very many physicians who have said to me that the practice of medicine is the greatest humbug the world ever knew. Can the reader believe that all physicians believe this? I have known very many clergymen who have admitted to me their profound unbelief in the fundamentals of their faith. Must we therefore conclude that all clergymen are thus insincere? We must not hold such a view.

In a world so full of myriads of forces of which we know only a few, who knows what lost or dormant sense may, under peculiar conditions, be revived, or what new channels of communications may be opened up? While a doubt remains, we should not profess to know. While we are not sure of another's scientific ability to test what he witnesses, we should not insist that he has been deceived. While we are not sure that all the phenomena of Spiritualism are to be explained on other grounds than those insisted on by Spiritualists, we should be glad to investigate them. Few of us are always beyond the need of help; and great as one's scholarship may be, and profound his philosophical learning, his ears should always be open, his eyes ever looking, for some still more confirmatory evidence of what the writer believes to be a truth, that the great and noble soul of man shall not lose its identity in death.

CHAPTER XXIX

THE UNIVERSAL PERSON

"AC mihi quidem veteres illi, majus quiddam animo complexi, multo plus etiam vidisse videntur, quam quantum nostrorum ingeniorum acies intueri potest; qui omnia haec, quae supra et subter, unum esse, et una vi atque una consensione naturæ constricta esse dixerunt—In my judgment those old writers, comprehending something more in their soul, saw much more than the acuteness of our men of genius enables them to observe: they saw that all things whatever there are above or below, are one, and bound together through one force and agreement of nature." (Cic. De Orat. III. 5.)

"There is one universe made up of all things, and one God, who pervades all things, and one substance and one law, and one common reason in all intelligent animals. . . . Constantly regard the universe as one living being having one substance and one soul." (Antoninus VII. 9; IV. 40.)

"All things obey and serve the universe, earth and sea and sun and the rest of the stars, and the plants of earth and animals. And our body obeys it also both in disease and in health." (Epictetus CXXXVI.)

"Whatever is, is in God; and nothing can either be, or be conceived to be, without God." (Spinoza.)

"Every single thing and event can only be thought as an activity, constant or transitory, of the one Existence, its reality and substance as the mode of being and substance of this one Existence, its nature and form as a consistent phase in the unfolding of the same." (Lotze I. 184.)

The fact of the existence of God has been admitted by the ablest and best that have ever lived; and although there have been, and are, some very good men who have denied or do deny such existence, we are convinced that the denial has been or is of the existence of some other one's god rather than of one's own. When we consider how greatly differ the various gods of the different nations — the Jews, the Egyptians, the Chinese, the Hindus, the Greeks and the Romans, one might wonder how great and noble souls could hesitate to deny the existence of such gods. But if any of those philosophers were asked for his opinion concerning the reasonableness of belief in an infinite, eternal, universal, and all-wise Being, the maker and supporter of the universe, and of all that are in it, he would certainly reply that such belief appears most agreeable to nature, although at the same time denying the existence of such god or gods as the people in general have conceived to exist, and made the object or objects of their sacrifices and adorations. It must be admitted that the conception of God with nearly all humanity is grossly anthropomorphic. By some God is affirmed to be in heaven, that he governs the various worlds by his power, not by his presence. The philosopher knows that such statement is absurd. The substance of God must be coextensive with his power; wherever his power is, there is also his essence. By some God is given such attributes as the philosopher knows can not characterize a good and wise being; by others God is said to have done such deeds, or to have acted in such manner, or to have desired such, as in the philosopher's judgment does not characterize the highest and best in all the universe, as conceived by the greatest and purest of men. Denying such existences, the philosopher has not unfrequently been declared atheistic. Few of the great leaders of men in philosophic thought have ever lived, who have not been maligned in this manner, and very many of them have suffered death at the hands of the ignorant. Wherever priests are in power, with no other priests to oppose them, there can no man safely possess a thought of his own, and every great soul's life is at the mercy of ignorant bigots; and the more exclusive the power of the priest, the greater the dominance and ignorance of the priesthood. It is liberalism and competition that have forced the priests to study in a measure, and to behave themselves decently, lest falling from their social position, they fail to have their bread provided them.

As the philosopher can not believe that God's substance is exclusively in heaven, and only his power on earth, so can he not believe that there is any world, or any point of space in the vast depths of the unbounded universe, where God is not substantially. Of all men he is most convinced that he can neither hide from God's gaze by descending into hell, nor by flying to the uttermost bounds of space; for he knows that wherever existence is, there is God the centre of it.

God is pure existence, simple substance, every point of which is the centre of infinite and universal being actuated with infinite thought and infinite consciousness. The universe itself is in and of and is God; and there is no point in the universe of which God is not the only substance. But considered in a narrower sense, the universe is rather that which flows out of the divine being than the divine being itself; and this follows from the fact that the universe which we behold and consider in general, is a kind of creation, of which we are made conscious through the action of the universal substance itself, which we do not know, on our senses, awakening in us a consciousness of the universe we do know. The universe we know is therefore a result of the interaction of two real worlds, the macrocosmos and the microcosmos, or the external universal substance and the mind of man. Every being without doubt sees therefore a modified universe, as no two persons are exactly alike; for every one's universe has passed through his own peculiar mental sieve, and is in a measure what he himself has made it. As the same bullet, reflected from a thousand different rocks, will move in all probability in as many different directions, and with different velocities, so the eternal unchanging abiding universal essence, when falling on and reflected from the mind of man, produces different results in different minds, leading one to affirm this, another to affirm that. But as all reflected bullets must move in some direction within the same sphere, so will all thoughts resulting from the reflected universe move in like manner within certain limits; and when these thoughts are compared, and the minds that gave birth to them asked to utter some one common united sentiment, we hear a voice as if ten thousand thunders rolling through the universe—

"Ecce Deus!"

The philosopher of all ages kindreds and tongues believes in God; and the opinions of all philosophers are not widely divergent concerning his nature and attributes. It is ignorance that is the mother of strife and quarrels.

God is the divine universe truly unseen to us, and unknown except inferentially from his works. But as the universe is necessarily one, and therefore God one, the little we know concerning him, and the little he reveals of himself in nature (which is the world flowing out of the divine being) must certainly agree with what is unknown of him, since he is the one only Universal Substance, unchangeable and eternally Conscious. And in every point of this infinite substantial sphere there is infinite power and infinite consciousness acting eternally and universally with infinite knowledge, wisdom, and goodness. Not less than this is the God of the universe.

It has not been uncommon for certain philosophers to call God the soul of the universe. Such thoughts were common with the great and noble Stoics, whether Greek or Roman, and to a less extent have been and are used by modern philosophers; but certainly God can not properly be called the soul of the universe. If God be the soul of the universe, he were not also the body. If he is the body as well as the soul, it is false to call him the soul; and if he be not the body, then another origin would of necessity have to be found for the material world. But we have elsewhere shown that two eternal origins are unthinkable and philosophically untenable. Therefore the soul and the body of the universe must have one common origin: each is rooted in, and maintained and guarded by, God, the only universal essence, or true being, out of which soul and mind and body, and whatever else there may be, arise. God is not therefore the soul of the universe, as mind is not man. The soul of the universe is the universal manifestation of law order reason and life; the body of the universe is its so-called material aspect or so-called matter, manifesting neither life nor care nor reason nor thought. The universe is not soul, is not body, but substance, of which eternal reality mind and matter are but evolutes, or different expressions of the same substance.

We do not like the expression that "God is in all." Such assertions are not unlike that most foolish expression, "All is God." "All" is a very ambiguous word. If by it is meant the sum total of universal existence, then is all God; but if by it is meant "anything" or "everything," then is all not God. If God were in all, then were there something not God for God to be in it. *A* can not be said to be in *B*, if *B* and *A* are the same; nor can *A* be said to be in *B*, if *A* and *B* were equal and the same substance. Strictly speaking, we must affirm that God is not in any part of the universe nor in all parts, and that no part is in him; but that the universe itself and all that is contained therein is God and God only.

For one to say "I am God," indicates ignorance, madness, or blasphemy (blasphemy is a child of ignorance); for one to say "All is God," indicates a lack of logical knowledge and precision, or perhaps a poetical sentiment, or euphemism; for one to say "God is all"—the sum total of universal existence, indicates the apprehension of eternal and unchanging truth. God is the Whole, the Being of beings, the Essence of essences, the Substance of substances.

Fountain of Life, vast Profundity, eternal Being, Majesty sublime, whose great heart throbs through the universal Whole, where transformation, new associations, and change constantly occur, but death can not come. Thou alone art unfading, imperturbable, and unalterable. Stars, constellations, systems, and cosmoses shall pass away, rolled up as a scroll, and the atom which once vibrated in man shall throb in a myriad other forms; but Thou, the never-aging, divine and infinite Self, remainest the same yesterday to-day and forever, the One and only adorable Majesty,

The Universal Person,
The Living Universe.

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THE LIVING UNIVERSE

BY

HENRY TRURO BRAY

M. A., M. D., B. D., LL.B., LL.D.

This is a book that has no superior. Every line is written with exact logical precision; and every part is so fitted to the whole that the reader, though blind, may finally be led to see the intimate relation of the seemingly disjointed parts of nature to the unspeakably glorious and adorable Universe itself. The work is a masterpiece of science and philosophy.

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